THEORY

OF

TIDES.

Bernardin de Saint Pierre (J. H.)

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THEORY OF TIDES.

TRANSLATED

FROM THE FRENCH

OF

MONSIEUR DE ST. PIERRE.

> " Thou com'ſt in ſuch a queſtionable ſhape,
> " That I will ſpeak to thee."——

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MVSEVM
BRITAN
NICVM

THEORY OF TIDES.

PREFACE.

THE following ſheets are a tranſlation of part of Monſieur de St. Pierre's Etudes de la Nature, and are preſented to the public, while the Navy is aſſembled, in hopes their ſubject may produce diſcuſſion.

The tranſlation was intended for the preſs in the fall of 1793, but was unavoidably poſtponed from time to time—the tranſlator indeed expected, much earlier than this, to have communicated with

Monſieur de St. Pierre, and to have requeſted a more detailed explanation on part of his Theory, and his further views on a ſubject ſo cloſely connected with the purſuits and the pleaſures of mankind.

A tranſlator on Natural Hiſtory cannot be too faithful and correct, in giving the preciſe ſentiments of his author;—to enſure ſo material a point, the tranſlation of this extract will be found as literal as the idiom of the language will admit.

Mr. Sulivan, in his View of Nature, has quoted ſome detached parts of the Etudes de la Nature, on polar fuſions;—upon ſuch ſubjects, it is but juſtice to the "benevolent and ſcientific St. Pierre," to give all he has given, and with that view, the preſent publication is recommended as a ſupplement to Mr. Sulivan's intereſting and extenſive work.

It will perhaps be objected, that a few pages on the ſubject of the Slave Trade, are not immediately connected with the object of the tranſlation,—but, the ſentiments contained in thoſe pages, are part of Monſieur de St. Pierre's able and moral works; and having read them with infinite gratification, the tranſlator does not feel himſelf diſpoſed to withdraw them from their original ſituation, at the moment in which the ſubject itſelf is under national conſideration.

BATH, *February*,
1795.

[illegible] Mr. [illegible] interesting and extensive work.

It will perhaps be objected, that many pages on the subject of the Slave Trade are not immediately connected with the ubject of the narrative,—but, the senti-ments contained in those pages, are part of [illegible] and [illegible] works; [illegible] with in-finite gratification, the author does not feel himself disposed to [illegible] them from their original situation, at the mo-ment in which the [illegible] is under national consideration.

THEORY OF TIDES.

PART I.

ETUDES DE LA NATURE,

VOLUME I. PAGE 159.

I REDUCE all currents of the ſea to two general currents. Both have their origin at the poles, and, in my opinion, are produced by the alternate fuſion of their ice.

The poles appear to me the ſources of the ſea, as mountains of ice are the ſources of principal rivers. I think the ice and ſnow of our pole annually renews the waters of the ocean, comprized between our continent and that of America, whoſe projecting and indented parts correſpond like the ſhores of a river. It is immediately ſeen in a map of the world, that the baſon of the Atlantic ocean narrows towards the north, and widens towards the ſouth; and that the projecting parts of Africa correſpond with the indented parts of America, which forms the gulph of Mexico; the projecting part of South America correſponds with the gulph of Guinea, ſo that in the figure of the ocean we diſcover the proportions, the windings, the ſource, and the mouth of a canal. Let us now obſerve that the ſnow and ice, in our hemiſphere, during the month of January, forms a cupola, whoſe arc is more than 2000 leagues in extent upon the two continents, with a thickneſs of ſome lines in Spain, ſome inches in France, ſome feet in Germany, ſome fathoms in Ruſſia, and ſome hundreds of feet north of the 60th degree; ſuch are thoſe ſeen by Ellis,* and other navigators, even in the midſt of ſummer, and which they computed at 1800 feet above the level of the ſea; and by following the proportions of increaſe with us, it is probable their elevation continues to ſwell towards the pole, which there muſt give them a depth which is not to be limited. From this ſimple ſtatement it is plain how enormous a quantity of water is congealed by winter in our hemiſphere, and that above the level of the ocean; ſo conſiderable is it, that I think myſelf founded in attributing to its periodic fuſion the general motion of our ſea, and that of our tides. The ſame reaſoning may be applied to the fuſion of the ice at the ſouth pole, which is there in ſtill greater quantities.

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* Voyage to Hudſon's Bay.

As yet no conſequences relative to the motion of the ſea, have been deduced from two ſuch maſſes of ice at the poles; yet they muſt cauſe either a very ſenſible augmentation to our waters, when they join them by the action of the ſun, which in part melts them every year, or a great diminution when they retire, by the evaporations which fix them in ice at the poles, where the ſun leaves them. I ſhall hazard a few opinions, which I may venture to ſay are at leaſt truly intereſting. I am about to deduce, from the mere fuſion of the ice at the poles, the general motion of the ſea, which has hitherto been ſuppoſed to depend on gravity, or the attraction of the ſun and moon upon the equator.

It will not be denied as a firſt principle, that tides and currents near the polar circle, flow in directions from the pole.

Fred. Martens, who, in his voyage to Spitſbergen, in 1671, puſhed as far as 81 deg, of north latitude, ſays poſitively, that the currents among the ice ſet to the ſouthward. He adds, that he can ſay nothing about the ebb and flow of the tides; let this be noticed.

Henry Ellis obſerved with aſtoniſhment, in his voyage to Hudſon's Bay, in 1746, and 1747, that the tides came from the north, and that their rapidity increaſed inſtead of diminiſhed, as he ran to the northward. He aſſerts that theſe effects, ſo contrary to thoſe upon our coaſts, where they come from the ſouthward, prove that the tides of thoſe ſeas neither ſtream from the Line, nor the Atlantic ocean. He attributes them to a ſuppoſed communication between Hudſon's Bay and the South Sea, which with infinite ardor he was endeavouring to diſcover, and which was the object of his voyage. But at this day we are perfectly well informed that no ſuch paſſage exiſts; the unſucceſsful attempts of Capt. Cook, undertaken at a very recent period, to diſcover one in the South ſeas, to the northward of California, place that beyond all doubt. Capt. Cook purſued the directions given long ſince by the renowned mariner Dampier, whoſe knowledge and inſight very materially aſſiſted him in his diſcoveries.

Ellis further obſerves, that the ſet of theſe North American tides were ſo rapid in Wager's Straights, in lat. 65° 37′ N. that he ran from eight to ten leagues per hour. He compares it to the gates of a mill. He obſerved that the ſurface of the water was freſh, which puzzled him extremely, and very conſiderably weakened his hopes of diſcovering a paſſage by that bay to the South ſeas. Still he conceived it to exiſt, as men pre-occupied with their own opinions are apt to reſiſt ſelf-evident propoſitions.

John Hughes, of Linſchoten, the Dutch diſcoverer,* had made nearly the ſame obſervations upon the courſe of the northern tides in Europe, when in Waigats Straights, in lat. 70° 20′ N. In the two voyages this obſerver made there in 1594, 1595, to diſcover a paſſage to China by the north of Europe, he repeats theſe obſervations, "We obſerved again, on the ſet "of the tides, what we had before noticed "with great exactneſs, that they came from "the eaſt." He alſo obſerved that the waters were brackiſh, or half ſalt, and attributes it to the melting of a prodigious maſs of floating ice, which blocked the paſſage into the ſtraights of Waigats, ſince ice formed from the ſea is freſh. But Linſchoten does not deduce any thing further than Ellis, from theſe tides of half freſh water, which are poured from the north, and, like the Engliſh navigator, full of his own project, attributes them to a ſea to the eaſtward beyond Waigats, by which he intended ſailing to China.

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* Firſt and Second Voyages to Waigats, Vol. IV. p. 204.

His fellow-traveller, the unfortunate William Barents,* who performed the ſame voyages in the ſame fleet, but in another ſhip, and who ended his days on the northern coaſt of Nova Zembla, where he had wintered, diſcovered to the north and ſouth of that iſland a continued current of ice, ſetting from the eaſt, of ſuch rapidity, that he, with Ellis, compares it to a ſluice. Theſe were iſlands of ice, which were meaſured as deep as thirty-ſix fathom under water, and ſixteen above it. This was in the ſtraights of Waigats, in July and Auguſt. He there met ſome Ruſſian fiſhermen of Petzora, navigating ſeas covered with floating iſlands of ice, in the bark of a tree ſticked together. Theſe poor fellows offered the Dutch ſome fat ſat geeſe, with ſtrong marks of kindneſs, for miſery is moſt apt to unite mankind, when they meet in remote climates. They taught him alſo that the ſame ſtraights of Waigats would be wholly cloſed towards the end of October, and that there was a method of going to Tartary, upon the ice, over the ſea called Marmora.

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* Second and Third Voyages of the Dutch, Vol. I.

It is clear that all the effects I now relate, can only proceed from the melting of ice ſurrounding the poles. I ſhall notice, that this ice, which ſtreams with ſuch rapidity from the north of America, and of Europe, during the months of July and Auguſt, contributes in giving us our high tides in the equinox of September, and that their fuſion ceaſes in the month of October, as thoſe of Waigats do; which is juſt the time our tides begin to take off.

It may be aſked, if the tides come from the north of America, and of Europe, why do they, on our coaſt, and on that of America, come from the ſouth?

I ſhould have done enough, if I only proved that the tides do not proceed from the preſſure or attraction of the ſun or moon upon the equator. I ſhould have ſhewn the incorrectneſs of our ſyſtem, which attributes them to thoſe cauſes; but I ſhall replace what I have deſtroyed by further remarks, and hope to prove that there is not any tide, on any coaſt, but owes its exiſtence to the fuſion of the ice at the poles.

An obſervation of Dampier's * immediately becomes the baſis of my reaſoning. From many experiments which he quotes, he has eſtabliſhed this axiom, "That currents are "felt only in the open ſea, and tides only upon "coaſts." This I conſider as data. The polar ſtreams, which are the tides of the north and eaſt to thoſe who are neighbours of the poles, or in bays communicating with it, take their general courſe down the middle of the Atlantic ocean, gravitating towards the Line, by the diminution of waters, which the ſun is continually evaporating, and by their return produce two contrary currents, or collateral eddies, ſimilar to thoſe on the ſides of a river.

I do not ſpeculatively ſuppoſe the exiſtence of theſe counter currents or tides, which is very

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* Treatiſe on Winds and Tides.

very much the habit of theoriſts, who create new cauſes, with the ſame eaſe that nature preſents new effects. Theſe eddies are hydraulic reactions, which are eſtabliſhed by common obſervation. Attend to the ſtream of a rivulet, you will frequently obſerve ſtraw floating along the edges and returning to the ſource, and when they have returned to the place where the eddy croſſes the general ſet of the water, you will obſerve them affected by oppoſite inclinations, turning and twiſting for ſome time, till they are again finally drawn into the general ſtream. Theſe eddies are ſtill more powerful, when the rivulet empties itſelf into a baſon, from which there is no outlet, for the reaction is then ſo conſiderable in the whole circumference of the circle, that the eddies bring every thing back to the very ſource of the ſtream.

Theſe eddies are ſo ſtrong on the borders of rivers, that boats take advantage of them to navigate againſt the ſtream. They are ſtill more powerful on the borders of lakes. Father Charlevoix,* who has given very judicious obſervations on Canada, ſays, that when he em-

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* Hiſtory of New France.

barked upon Lake Michigan, he made eight leagues a day, by the help of theſe eddies, though he had the wind againſt him. He ſuppoſes, with much reaſon, that the rivers running through this lake produce in the middle a regular ſtream; for he expreſsly ſays, "The "great ſtreams are only felt in the middle, "creating on the ſhores eddies or counter "currents, which are made uſe of when work-"ing cloſe in ſhore, which thoſe who navigate "in bark canoes are under the neceſſity of "doing."

Dampier is replete with obſervations on theſe counter currents of the ſea, which are very common, particularly among tropical iſlands. He frequently mentions the extraordinary effect produced by the ſhock of eddies meeting regular tides; but as he did not conſider the tides themſelves as eddies of the general current of the Atlantic, or, I believe, even ſuſpected the exiſtence of that general current, though he has written at large upon the two ſets or monſoons of the Indian ſea, I ſhall notice ſome facts which eſtabliſh the greateſt conformity with thoſe which Dampier obſerved in the Indian and South ſeas. Theſe facts will prove, and I think moſt evidently ſo, the exiſtence of theſe polar fuſions, for wherever on their paſſage ſouth they meet their own eddies, which are returning north, they produce by their ſhock the moſt rapid tides, and take the moſt oppoſite directions. Let us only conſider them in the north of Europe, where they begin to leave the coaſt, and paſs into the open ſea. Pontoppidan ſays, in his Hiſtory of Norway, that there is beyond Bergen a place called Maleſtrom, much dreaded by mariners, where the ſea forms a prodigious vortex of many miles in diameter, and by which many veſſels have been ſwallowed up. James Beverel poſitively aſſerts,* that in the Orkneys there are two oppoſite tides, the one coming from the N. W. the other from the S. E.; that they throw their waters to a very conſiderable height, as if endeavouring to deſtroy the iſthmus which ſeparates them. The Orkneys are ſituated a little ſouth of the latitude of Bergen, and in the continued projection of the north coaſt of Norway, that is, at the point of union of the polar fuſions, and their eddies.

Other iſlands are ſimilarly circumſtanced. The gulph ſtream, which ſets ſo rapidly to the

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* Voyages, Beauties of Scotland.

northward, between the continent of America and the Leeward iſlands, meets the general current of that ſea, and produces tides the moſt irregular, and ſimilar to thoſe in the Orkneys.

Theſe eddies of the Atlantic ocean cauſe the European and American tides, which run north upon our coaſts, while its general ſtream is to the ſouthward, at leaſt during the ſummer. I could relate a thouſand other obſervations on the exiſtence of theſe eddies, but a ſingle one, more general than any I have named, will be ſufficient, both from its importance and authenticity; it was the firſt, and is perhaps the laſt made in Europe—I mean the obſervation of Chriſtopher Columbus, on his departure for the diſcovery of the new world. He ſailed from the Canary iſlands towards the beginning of September, and ſteeréd weſt. When two or three hundred leagues from the land, he found that he got to the ſouthward, which extremely alarmed his crew, who thought the ocean was running that way to a precipice. However, as he neared the Weſt Indies, he obſerved the tides going north again. His journal may be ſeen in Herrera.

My opinion is, that the general ſtream which flows from our pole during the ſummer, with ſo much rapidity, and with ſo much violence at its ſource, as experienced by Ellis and Linſchoten, traverſes the equinoctial line, not being in the leaſt impeded there by the fuſion of the ſouth pole, which in that ſeaſon is accumulating ice. For the ſame reaſon I conceive that it runs beyond the Cape of Good Hope, whence it takes a direction for the torrid zone, being drawn there by the loſs of water, daily exhaled by the ſun, and being directed to the eaſt by the form of Africa and Aſia, it determines the ſet of the Indian ocean, contrary to its natural ſtream. In ſhort, I reckon it the firſt cauſe of the eaſtern monſoon, which arrives in the Indian ſeas in April, and ceaſes in September.

I alſo imagine that the general ſtream, which, during our winter, leaves the ſouth pole, then heated by the ſun, reſtores the Indian ſea to its natural weſtward direction, which is alſo inclined that way from the general tendency of the winds from the eaſtward, which prevail in the torrid zone when nothing deranges their courſe. I further ſuppoſe this ſouthern ſtream penetrates into our Atlantic ocean, and is directed in its progreſs towards the north by the poſition of America, cauſing many other changes in our tides. And Froger* obſerves, that at the Brazils "the currents "follow the ſun—they go north with him, and "with him ſouth." Thoſe who have experienced the fuſions of the ſouth pole, beyond Cape Horn, have found, during the ſummer of the ſouth pole, the tides run to the northward, as obſerved by Schouten, who diſcovered the ſtraights Le Maire, in January 1661; but, on the contrary, thoſe who remained there during the winter perceived that the tides ſet to the ſouthward, but came from the north, which was remarked by Fraſer in the month of May of the year 1712.

It appears to me, that by the polar fuſions, the principal phenomena of our tides may be explained. It is clearly ſeen, why thoſe of the evening are, in ſummer, ſtronger than thoſe of the morning, becauſe the ſun acts with more effect in the day than in the night upon the ice at our pole, and under our meridian. This effect is ſimilar to that of intermittent fountains, which flow from mountains covered with ice, and give more abundantly in the evening than in the morning. It is clear why our morning tides, during the winter, are fuller than thoſe of the evening, and why the ſucceſſion of our tides changes every ſix months, according to Bouguer's obſervations,* who conſiders the fact as aſtoniſhing, without aſſigning any reaſon; for the ſun being then on the ſouth pole, the effects of the tides muſt neceſſarily be oppoſite, the cauſes which produced them being reverſed.

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* Voyage to the South Seas.

But I have ſome harmonies between the ſea and the poles, ſtill more extenſive and extraordinary. During the ſolſtice we have the loweſt tides in the year; it is alſo the time at which there is the greateſt accumulation of ice at the two poles, and conſequently the leaſt water in the ſea; and for this reaſon, the winter ſolſtice is, with reſpect to us, the coldeſt ſeaſon of the year, and there is then at our pole, and on our hemiſphere, the greateſt poſſible volume of ice. It will be ſaid, it is the ſummer ſolſtice for the other pole; but there is then little ice melted at that pole, becauſe the effect of the greateſt heat is only felt, as with us, when the globe has an acquired heat, which only takes place during the ſix weeks ſucceeding the ſummer ſolſtice, giving us in our ſummer the hotteſt or dog-days.

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* Traité de Navigation, page 153.

On the other hand, it is during the equinoxes that we get the higheſt tides; and this is preciſely the time in which there is leaſt ice on both poles, and conſequently the greateſt quantity of water in the ſea.

In the September equinox, the greateſt part of the ice at our pole, which has borne all the heat of ſummer, is melted, and that at the ſouth pole begins to melt.

It is further to be obſerved, that the tides of the March equinox are greater than thoſe of September, becauſe it is the cloſe of the ſummer at the ſouth pole, which has infinitely more ice than ours, and conſequently yields to the ocean a greater ſupply of water; it has more ice, becauſe the ſun is ſix days longer in our hemiſphere, than in the ſouthern. If I am called upon to account for the ſun's not giving an equal portion of time and heat to each hemiſphere, I ſhall transfer the taſk to the learned; but I ſhould conjecture it the will of Divine Goodneſs, which thought fit to make a partition favourable to that portion of the world which contains the greateſt quantity of land, and the greateſt number of inhabitants.

I ſhall ſay nothing on the intermitting of theſe polar fuſions, which give on our coaſts two floods and two ebbs, in about the ſame time that the ſun, making the round of the world in our hemiſphere, alternately heats two continents, and two ſeas, that is, in twenty-four hours, during which time its influence is twice in action, and twice ſuſpended. I ſhall not enter into their daily later return, by about three quarters of an hour, which ſeems determined by the different diameters of the polar cupola of ice, whoſe margin, melted by the ſun, is every day diminiſhed and removed further from us, and whoſe fuſions muſt conſequently require more time to reach the Line, and to return from it to us. Nor ſhall I do more than ſuggeſt the affinity which theſe periods of the poles bear with the phaſes of the moon, particularly when full, for her rays have an evaporating warmth, proved by late obſervations at Rome and Paris. I ſhould be obliged to relate a ſuite of facts and authorities, which would lead me too far.

I ſhall ſtill leſs engage to reaſon on the tides of the ſouth pole, which, during their ſummer, ſtream immediately from the ſouth and ſouth-eaſt, with a heavy boar, as eſtabliſhed by the Dutchman, Abel Taſman, in January and February 1692; nor ſhall I enlarge on their irregularity on the ſhores of that hemiſphere, ſuch as in New Holland, where, in the month of January, 1688, Dampier, to his utter aſtoniſhment, found, that the higheſt tide (which came from the E. ¼ N.) only reached him the third day after full moon, and his crew believed that their ſhip, which was laid on ſhore to repair, would remain ſo, from the impoſſibility of floating her.* I ſhall ſay nothing on thoſe in New Guinea, where, towards the end of April, the ſame navigator met many different tides in the ſame night, which came from the weſt, in rapids;—nor of the little riſe of the tides on the coaſt of Brazil—in the greateſt part of the South ſea—in the Eaſt Indies, where they only flow from five to ſeven feet, while Ellis has found them of twenty-five feet at the mouth of Hudſon's Bay, and Sir John Narbrough of twenty feet at the entrance of the ſtraights of Magellan—of their courſe towards the equator in the South ſea—of their retarded and accelerated motions upon its coaſts—of their ſet ſometimes to the eaſt, ſometimes to the weſt, according to the monſoons—nor, in ſhort, of their growth, which increaſes as they near the pole, and diminiſhes as they depart from it, even between the tropics; proofs, in my opinion, that their ſources are not under the Line, and that their motions do not depend upon attraction, or the preſſure of the ſun and moon upon that part of the ocean, for theſe powers would certainly act there with the greateſt energy, and at intervals as regular as the periods of theſe bodies. To me they ſeem to depend wholly on the accumulated heat of theſe planets over the poles of the world, whoſe irregular fuſions, not being reſtrained in the ſouthern hemiſphere, as they are in the northern, by the canal between the two hemiſpheres, produce, on the coaſts of the Indian and Eaſt ſeas, uncertain and irregular expanſions.

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* Dampier's Voyage—Treatiſe on Winds and Tides, page 378, 379.

It is then ſufficient to admit the alternate fuſions of the polar ice, which cannot be ſubject of doubt, to explain, with the greateſt facility, all the phenomena of currents and tides. Theſe phenomena preſent, in the journals of the ableſt voyagers, perpetual obſcurity, and innumerable contradictions, whenever they attempt to account for theſe effects by the continual preſſure of the moon and the ſun on the equator, without noticing the following circumſtances;—firſt, the alternate currents of the poles, which ſet towards the equator;—ſecondly, their eddies, which, in returning to the poles, occaſion the tides;—thirdly, the changes which the winter and ſummer occaſion in theſe two motions.

It has indeed been imagined, and that lately, that the ſea was diveſted of ice at the poles, from this ſtrange idea, that the ſea only froze upon the borders of the land; but this hypotheſis was made by men in their cloſets, in oppoſition to the experience of the firſt navigators. The efforts of Capt. Cook towards the ſouth pole, have removed this error. That enterprizing mariner was never able, during the month of February, the ſouthern dog-days, to approach nearer that pole, where there is no land, than the 70th degree, that is, than 500 leagues, though during the ſummer he circumnavigated the whole of the cupola. This diſtance is not more than half the amplitude of the cupola, and this he only reached through an inlet, in one part of its circumference, for it was every where elſe much more extended.

I apprehend theſe inlets or bays are formed in the ice, by the influence of the neareſt land, where nature has arranged ſandy zones, which accelerate the fuſion of the polar ice at the proper ſeaſon. Such, to mention one, for I ſhall not at this time open my ſpeculations on the plans of that admirable architecture, ſuch the long layers of ſand which interſect South America, near the ſtraights of Magellan, and thoſe of Tartary, which begin in Africa at the Zara, or Deſert, and end in the north of Aſia. The winds in ſummer convey the ignited particles, of which thoſe zones abound, towards the poles, where they quicken the powers of the ſun acting upon the ice. It is eaſy to underſtand, without experience, that the ſands increaſe the heat of the ſun by the action of their reflecting and brilliant particles, and that they preſerve their heat for a long time in their openings ; at leaſt it is certain, that the greateſt inlets in the ice at the poles are conſtantly found in the tract of the warm winds, and ſubject to the influence of theſe ſandy regions ; this I could eaſily prove, if the fact were doubted. We can trace the progreſs of it without leaving our continent, or even our gardens. In Ruſſia, the firſt appearance of thaw, in its rivers and lakes, takes place on their borders, and the fuſion of their ice is accelerated in proportion to the quantity and vicinity of ſand, and to its ſouthern poſition. We perceive the ſame effects in our gardens towards the end of winter. The ice which is formed upon ſand in alleys melts firſt, that on earth next, and laſtly that in ponds. The thawing of ponds begins at the ſides, and the time it takes is proportioned to its extent; ſo that the ice in the middle, which is the furtheſt from the ſide, is the laſt melted.

There is no doubt that the poles are covered with a cupola of ice; it is eſtabliſhed by diſcovery, and by common ſenſe. A curſory view has been thrown on that of our pole, which is covered in winter to an extent of more than 2000 leagues upon the two continents. It is not ſo eaſy to determine its height at the center, and under the pole itſelf, yet it cannot but be of prodigious elevation.

Aſtronomy frequently preſents us with ſo conſiderable a ſhadow of it in the heavens, that the rotundity of the earth appears viſibly altered.

I quote what I found on this ſubject in the Engliſh author Childrey.[*] This naturaliſt ſuppoſes, as I do, that the globe is covered with ice at the poles, at ſuch elevation, that its figure is viſibly prolonged to that of an oval. This he elucidates by two very remarkable obſervations. And I am further obliged, he adds, to adopt this paradox, becauſe it peculiarly ſerves to ſolve an important difficulty, which much embarraſſed Tycho Brahe, and Kepler, touching the central eclipſes of the moon, which happen near the equator, ſuch as that obſerved by Tycho in 1588, and that by Kepler in 1624, of which he ſays,[†] "It is to be obſerved " that this eclipſe of the moon (the ſame which " Tycho in 1588 obſerved to be total and cen- " tral) very evidently refuted calculation; for " not only the continuance of the moon in total " darkneſs was ſhort, but the duration of the " reſt, both before and after it, was ſtill ſhorter,

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[*] Natural Hiſtory of England, page 246 and 247.

[†] "Notandum eſt, hanc lunæ eclipſum, (inſtarillius " quam Tycho, anno 1588 obſervavit totalem et proximam " centrali) egregié calculum fefeliſſe, non ſolum mora totius " lunæ in tenebris brevis fuit, ſed et duratio reliqua multo " magis; perinde quaſi tellus elliptica eſſet, dimitientem " breviorem habens ſub æquatore; longium a polo uno " ad alterum."

“ as if the earth was eliptical, having a leſs “ diameter under the equator, and a longer one “ from pole to pole.”

The half-melted iſlands of ice, which annually quit the circumference of the cupola, and which are met at great diſtances from the pole, floating at ſea in the 55th degree of latitude, are ſo lofty, that Ellis, Martens, Cook, and other as accurate explorers to the north and ſouth, repreſent them at leaſt as lofty as ſhips under ſail. Ellis himſelf, without heſitation, gives them from fifteen to eighteen hundred feet of elevation. They agree in relating that the ice reflects light ſo ſtrongly, as to ſhew itſelf before it is on the horizon.

I ſhall remark here, that our northern lights may very probably be owing to this reflection of the polar ice, whoſe altitude may, after further experience, be determined by the extent to which theſe lights are perceivable.

Denis, governor of Canada, ſpeaking of the ice, which every ſummer paſſes from the north to the banks of Newfoundland, ſays, thoſe iſlands are higher than the tops of Notre Dame, and that they are ſeen, and their cold is felt at the diſtance of fifteen and eighteen leagues. He adds, they are ſometimes in ſuch numbers, being all brought by the ſame wind, that veſſels on the cod fiſhery have fallen in with them, extending 150 leagues; and that others have coaſted them from twenty-four to forty-eight hours, with a freſh wind, and carrying a preſs of ſail, without getting to their extremity. In this manner veſſels run down their whole extent to find an opening to puſh through. If they find one, they paſs theſe ſtraights, otherwiſe they muſt run on to the end. This ice does not melt till it meets the warm waters of the ſouth, or till the winds drive them to the coaſt. Some have grounded in twenty-five and thirty fathoms. Judge hence of their altitude, without reference to what is ſeen above the level of the ocean. Some fiſhermen have aſſured me they ſaw one ground on the banks in forty-five fathoms, which was full ten leagues in circumference. It muſt have been extremely high.*

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* Monſieur de St. Pierre might have aſſerted theſe bodies of ice to be much more conſiderable than he here ſtates them. They have reached Barbadoes. I am collecting facts on this ſubject.

TRANSLATOR'S NOTE.

We muſt notice that this ice is more than half melted when it reaches the banks; for the iſlands ſeldom go further. The heat of ſummer releaſes them from the north, and they make their way ſouth, partly by their own thawing, which ſets them towards the Line, where the waters ſtream to replace that which the ſun there evaporates.

The ice of the poles, of which our navigators only ſee the fragments and remains, muſt at their center have an elevation proportioned to their baſe: I cannot but conſider the two hemiſpheres as two mountains applied to each other at the equator; the poles as the frozen ſummits of theſe mountains; and the ſeas as rivers iſſuing from theſe ſummits. If, then, we compare the proportion which the glaciers of Switzerland bear to their mountains, and to the rivers which flow from them, we ſhall be enabled to form ſome idea of that which the glaciers of the poles have with the earth and the ocean.

The Cordeliers of Peru, which are but molehills, compared to the two hemiſpheres, and whoſe rivers are but ribands of water to the ſea, have glaciers of ice from twenty to thirty leagues wide, and beſet at their center with pyramids of ſnow, from twelve to fifteen hundred fathoms high. What then muſt be the elevation of the two frozen polar cupolas, whoſe baſes in winter are two thouſand leagues in diameter? I have no doubt but their depth at the poles will give the earth the ſhape of an ellipſis in central eclipſes of the moon, as obſerved by Tycho Brahé and Kepler.

I deduce another inference from this configuration. If the altitude of the polar ice is capable of changing the ſhape of the world, their weight muſt be ſufficiently conſiderable to influence its motion on the ecliptic; and there is a very ſingular accord between the motion by which the earth every year alternately preſents its two poles to the ſun, and the regular annual fuſions of the polar ice. I therefore conſider the motion of the earth to be the effect of theſe fuſions. Admitting with aſtronomers the laws of attraction among the ſtars, the earth muſt certainly preſent its heavieſt part to the ſun which attracts. That part muſt be one of the poles when ſurcharged with a cupola of ice, of two thouſand leagues in extent, and of an elevation ſuperior to that of continents. But as the ice of the pole, whoſe weight inclines it towards the ſun, is melted by it, in its approach to a vertical poſition; and on the contrary, the ice of the oppoſite pole is increaſed, as it increaſes in diſtance from the ſun; it neceſſarily follows, that one pole getting heavier, and the other getting lighter, the center of gravity will be conſtantly changing, and that from this reciprocal balance ariſes that rotation of the earth in the ecliptic, which gives us the returns of ſummer and winter.

It would follow from this verſatile gravity, that our hemiſphere, which has more earth in it than the ſouthern, and which is therefore heavier, muſt be longer preſented to the ſun; and this is exactly the caſe, as we have five or ſix days more ſummer than winter. It alſo follows, that our pole cannot loſe its center of gravity till the oppoſite pole is loaded with a weight of ice ſuperior to that of ours, and of the ice on our continent. This likewiſe is the caſe, for the ice of the ſouth pole has more extent and altitude than that of our pole, ſince navigators have only penetrated to the 70th degree of ſouth latitude, while they navigate to the 82d degree of north latitude. If it ſhould be aſked, why nature has divided this globe into hemiſpheres, one of which contains the greateſt quantity of land, and the other of ſea, I think we may conclude it ſo ordered, that this annual motion of the globe might be conſtantly kept up. It alſo ſeems evident that the ſouth pole is placed directly in the center of waters, without having any land near it, that it might load itſelf with a greater quantity of marine congealment; and that this maſs accumulated round the pole might balance the weight with which our hemiſphere is poiſed.

[illegible] of [illegible]

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second.

THEORY OF TIDES.

PART II.

ETUDES DE LA NATURE,

VOLUME III. PAGE 437.

THE Atlantic hemiſphere is here repreſented,* with its ſources, ice, canal, currents, and tides, in the months of January and February.

Though I am obliged to repeat ſome obſervations which I have before touched upon, I ſhall add others, worthy, I hope, of all the reflexion my reader can beſtow.

It is, in the firſt place, to be noted, that the globe is not deſcribed in the form given it by geographers.

The following diviſions are diſtinguiſhed :—firſt, the ſources of the Atlantic ocean, which in ſummer proceed from the north pole ;—

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* Plate I.

ſecond, its canal, formed by the projecting and indented parts of the two continents;—and, third, its mouth, contained between Cape Horn and the Cape of Good Hope, by which the ocean, during the ſummer, diſcharges itſelf into the Indian ſeas.

The oppoſite coaſt of this hemiſphere, though yet but little known, would, like ours, exhibit a fluid canal, with the ſame attendants, ice, ſources, currents, and tides, produced, not by continents, but by the projection of iſlands and ledges of rocks, which, during our winter, direct the fuſions of the ſouth pole into the Indian ſeas. However intereſting theſe projections of the globe would be, it was not poſſible for me to be at the expence of engraving them; for it had been neceſſary to give each hemiſphere in its ſummer and winter ſtate; to follow the various currents of each ſeaſon, and to give a bird's-eye view of the poles themſelves both in winter and in ſummer; to deſcribe the extent of the cupolas of ice which cover them, and trace the currents iſſuing from them in the different ſeaſons. It had required at leaſt eight plates, upon a larger ſcale than the preſent, to develope with preciſion the harmonies of this part of nature.

The mere diſplay of the Atlantic hemiſphere, in January and in February, will ſuffice to explain what has been advanced with reſpect to the ice of the poles, and their periodic fuſions. We ſhall in ſucceſſion review their ſources, their ice, their canal, their currents, their tides, and even their mouths.

The ſources of the Atlantic ocean are in ſummer at the North Pole, in the Baltic, Hudſon's Bay, Bafin's Bay, Straights of Waigats, &c. &c. It may be ſeen on a globe in relief, that the ſources which form the beginning of the Atlantic canal move about the pole, forming a ſpiral, ſomething like that of a ſerpentine river, round the mountain from which it deſcends, gathering in its way all the ſtreams from the north, and carrying their waters into the Atlantic ocean;—and hence I conclude, that there is proportionably much leſs polar fuſion in the part of the ſouthern ocean oppoſite to it. We ſhall find that the extremities of the two general currents of the poles are, by the proceſs of nature, brought back into the original Atlantic current, after making the circuit of the world. I muſt notice, that in oppoſition to the *ſources*, I give the extremity of theſe currents the appellation of *mouths*.

Let us now only conſider their ſources. It is evident the water from theſe ſources muſt ſtream towards the Line, where they replace thoſe daily evaporated by the ſun, and that they alſo have an elevation which facilitates their motion. Not only the ice from which they melt is higher than the ſea, but the poles themſelves have an elevation, which is conſiderable. I reſt this aſſertion, in the firſt inſtance, on the obſervations of Tycho Brahé and Kepler, who ſaw the ſhadow of the earth oval at the poles, in central eclipſes of the moon; and, ſecondly, on the authority of Caſſini, who gives fifty leagues more to the polar than equatorial diameter of the earth. In the next place, I have the eſtabliſhed experiments of the Academy of Sciences for me, which have been laid aſide ſince the opinion of depreſſed poles has prevailed. For inſtance, we know that as we aſcend a mountain, mercury falls in the barometer. But mercury falls in the barometer in proportion as we go north. It falls in our climate about one line, if raiſed eleven fathoms. According to the hiſtory of the Academy of Sciences,* the weight of a line of mercury is equal at Paris to ten toiſes † five feet, or ſixty-five feet; while, in Sweden, ten toiſes,† one foot, ſix inches, or ſixty-one feet ſix inches,* produces a fall of one line. Therefore the atmoſphere of Sweden is leſs elevated than that of Paris, and conſequently the ſurface of the country is higher.

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* 1712, page 4.

† Fathoms.

To this may be added the obſervations of northern navigators, who, as they have neared the pole, have found the ſun to be gradually higher. This cannot be attributed to the mere refraction of the atmoſphere. According to the academician Bouguer,† "Refraction to ap-
"pearance raiſes the object, and it is known
"by a great number of experiments, that when
"they ſeem to us on the horizon, they are
"actually 33 or 34 minutes below it. In
"climates where the air is more denſe, the re-
"fractions muſt be ſomewhat ſtronger, and all
"things conſidered, they actually are rather
"ſtronger in winter than in ſummer. In com-
"mon practice at ſea, it is not neceſſary to take
"notice of this ſmall difference, and the table
"given is ſufficient." And in his table he gives 34 minutes as the greateſt refraction of the ſun on the horizon, for all parts of the world.

* French meaſure, as to

† Traité de Navigation, b. 4. ch. 3. ſect. 3.

world. But how ſhould it happen that Barents ſaw the ſun upon the horizon at Nova Zembla on the 24th of January, in the 5° 25′ of Aquarius, while it ought to have been in the 16° 27′ to be viſible in latitude 63 N. where Barents then was? The refraction of the ſun upon the horizon was nearly 2° 30′, that is, more than four times as much as Bouguer eſtimated it, as he only gave it 34′ for all climates. Indeed Barents was extremely ſurprized to ſee the ſun fifteen days ſooner than he expected, and he only aſcertained its being the 24th of January, by obſerving that very night the conjunction of the moon and of Jupiter, given for Venice in Joſeph Scala's Ephemeris, for one A. M. of that night, and which took place at Nova Zémbla at ſix in the morning, in Leo, which both gave him the longitude of his hut in Nova Zembla, and the certainty of its being the 24th of January. A refraction of 2° 30′ is certainly very great. I think half of it may be attributed to the very refracting atmoſphere of Nova Zembla, and the other half to the actual elevation of the obſerver, on the horizon of the pole. Thus Barents perceived from Nova Zembla, the ſun at the equator, as a man diſcovers it ſooner from the top of the hill than from its foot.

Nature, perhaps, to compenſate the poles for the long abſence of the ſun, directs the moon to the deſerted half, and cryſtallizes and reduces the waters which cover it to brilliant ſnows. She renders the atmoſphere more refracting, that the preſence of the ſun may be the longer continued, and the ſooner reſtored. We may alſo conclude that ſhe has lengthened the poles themſelves, that they may, for a greater length of time, receive the ſolar influence.

It is true, celebrated academicians have laid it down as a firſt principle, that the earth is flattened at the poles. I quote what Bouguer ſays, who was himſelf employed with others to meaſure near the equator a degree of the meridian, which they found conſiſted of 56748 toiſes or fathoms.* “ But,” he obſerves, “ it is well worthy of notice, that “ the terreſtrial degrees in other latitudes are “ not found the ſame, where ſimilar experi- “ ments have been made, and the difference “ is too great to be attributed to the inevitable “ inaccuracies of obſervation. A degree under “ the polar circle was found to contain 57422

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* French meaſure, as to

“ toiſes or fathoms. It therefore neceſſarily “ follows that the earth is not round, but is “ higher at the equator than at the poles, “ which agrees with other experiments, which “ it is needleſs to mention here. The curve “ of the globe upon a meridian is more ſudden “ near the equator, for the degrees are leſs; “ on the contrary, the globe is flatter towards “ the poles, the degrees there being greater.”*

I own the inferences I deduce from theſe obſervations are perfectly the reverſe. I conclude that the globe is lengthened at the poles, becauſe the degrees of a meridian are there greater than thoſe at the equator. This is my demonſtration. If a degree of the meridian taken at the pole, were applied to a degree of a meridian taken at the equator, the firſt degree, which is 57422 toiſes or fathoms, would exceed the ſecond degree, which is 56748 toiſes or fathoms, by 674 toiſes or fathoms, depending on the academical account. Then, if the whole arc of the polar circle, which is 47 degrees, were applied to an arc of 47 degrees at the equator, a ſuperior elevation would evidently appear in the firſt, the degrees being larger. The polar arc could not coincide with the equatorial arc, though each on the ſame meridian, each of 47 degrees, and therefore each with the ſame length of chord. For the firſt ſurpaſſing the ſecond by 674 fathom in each degree, it is clear it would ſwell above the circumference of the globe, and no longer be part of the ſecond circle; and would form a flattened projection upon the globe. To render the thing ſtill eaſier, let us ſuppoſe the outline of the poles to be an arc of 47 degrees. If an arc be drawn within this outline, as is done in flattening the poles, it will be leſs than the outward arc, becauſe contained within it; and the more it is flattened, the leſs the arc will become, becauſe it draws nearer and nearer to the chord of the arc, that is, to a right line. Therefore the 47 degrees or diviſions of this interior arc, will be ſeparately and collectively leſs than the 47 degrees of the outward arc. But as the degrees of the polar arc are, on the contrary, greater than thoſe of the equatorial arc, it follows, that the projection of the firſt muſt be greater than that of the ſecond, and therefore that the projection forms a lengthened ellipſis.

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* Bouguer Traité de Navig. b. 2. chap. 14. art. 29.

Let X* be the unknown arc of a meridian exceeding the arctic polar circle ABC, and let DEF be an arc of the ſame meridian under the tropics. Theſe two arcs are each ſuppoſed of 47 degrees; but though they have equal angles AGC and DGF, they have not coinciding arcs, for, according to our aſtronomers, one degree of the meridian in the polar circle is 674 toiſes or fathoms greater than one degree of the ſame meridian near the equator. It follows, then, that the unknown polar arc X of 47 degrees, exceeds in length the 'equatorial arc DEF, alſo of 47 degrees, by 47 times 674 toiſes or fathoms, that is, by 31678 toiſes or fathoms, or 12½ leagues. It now remains to be found whether the unknown polar arc X is contained within the circle, as AhC, or if it coincides with it, as ABC, or if it projects beyond the circumference, as AiC.

The unknown polar arc X, cannot be contained within the globe, as AhC, as is pretended by our aſtronomers, who ſuppoſe it flattened; for if it were contained, it would evidently be leſs than the arc ABC, according to this axiom, that the greater cannot be contained in the leſs. And the more this arc was flattened, the leſs extent it would have, and would by ſo much approach to the chord, or the right line AKC.

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* Plate II.

Again, this polar arc cannot coincide with the arc ABC, becauſe it exceeds it by 12½ leagues. It then is part of an arc which projects on the circumference of the globe, as AiC. Therefore the globe is extended at the poles, the degrees being there greater than at the equator. And our aſtronomers have erred, in concluding, from this circumſtance, that the poles are flattened.

I ſhall finiſh this demonſtration by a compariſon more trivial, but equally juſt. If you divide the two circumferences of an egg into 360 degrees, would you conclude that the egg was flat at its extremities, becauſe the degrees of circumference in the length were larger than the degrees of circumference in the breadth? What appears ſtrange is, that the academicians make uſe of nearly the ſame figure to eſtabliſh oppoſite concluſions. They liken the globe to a Dutch cheeſe, and ſuppoſe the world much ſwelled at the equator. "The curve of the "earth," ſays Bouguer,* "is more ſudden on

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* Traité de Navigation, b. 2. ch. 14.

“ the meridian at the equator, becauſe the “ degrees are ſmaller; on the contrary, it is “ flatter at the poles, becauſe there the degrees “ are larger. It was imagined that the equator “ was only diſtinguiſhed by the greater rapidity “ of movement performed in the twenty-four “ hours; but it is poſſeſſed of much ſtronger “ diſtinction, having a regular elevation of about “ 6½ leagues all round the earth, at an equal “ diſtance from the poles.”

We ſee the ſtrange conſequence which reſults from flattening the poles of the earth, and from the increaſe of a degree in that part of the meridian, which neceſſarily gives a ſwell to the polar circumference.—Thoſe which might be drawn from the elevation and more ſudden curve of the equator, would not be leſs extraordinary. For if theſe are both facts, there would not exiſt any ſea under the equator, becauſe it would then be determined by the elevation of 6½ degrees, and by the more ſudden curve of the earth to forſake the Line, and by its weight to run off towards the poles, flattened and nearer the center, and to reſtore the ſpheric ſegment which the academicians have retrenched; ſo that with this hypotheſis, the ſea would cover the poles, and to a great depth, while continents alone could exiſt near the Line. But geography proves the reverſe, for it is in the neighbourhood of the Line that the greateſt ſeas and the loweſt lands are found; and the high lands and ſhoals are moſt frequent in the vicinity of the north pole.

Let us now conſider the polar ice. Though in the figure* it is ſhewn in the diſtant and leſs viſible parts of the globe, it is eaſy to eſtimate its extent by the arc of the meridian it occupies. At the ſouth pole, where the ice is in the leſſer quantity, having undergone the heat of ſummer in that hemiſphere, it ſtill extends from the pole to at leaſt the 70th degree, and forms a cupola, whoſe arc has more than 40 degrees, of at leaſt twenty-five leagues to a degree (the degrees being there larger than near the equator, according to the academicians), and gives a diameter of more than one thouſand and twenty leagues, or a circumference of more than three thouſand leagues. Theſe dimenſions cannot be ſubject to doubt, being founded on Capt. Cook's laſt obſervations, who circumnavigated the ſouth pole in the heat of its ſummer. The ice of the north pole, in the figure, appears much more extenſive, becauſe it is repreſented* during its winter. To each

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* Plate I.

is given a frozen cupola, of about twenty-five leagues of elevation under the pole. I ſhall not repeat here what I have noticed of the height of the iſlands of ice met with at ſea, towards the extremity of the cupola, which are from twelve to fifteen hundred feet high. It was my wiſh to have repreſented round the cupola a ſort of glory, or aurora borealis, which would have ſhewn their circular extent, and added to the pictureſque appearance of the globe, by making it radiant. For the ſouthern pole has alſo its nocturnal lights, as obſerved by Cook, and it appears they owe their exiſtence to the polar ice. But Mr. More, jun. who drew the plates of this work, and more particularly this plate, with the readieſt capacity and goodwill, convinced me there was not ſpace enough in the deſign. He has, however, rendered the polar ice ſufficiently clear for obſervation, without loſing the ſhape of the iſlands and continents which it covers.

With reſpect to the Atlantic canal, the projecting and indented parts of the two continents are perceived to be correſponding. If to its ſerpentine ſource of the north, which ſeems to wind round our pole, be added its wide and diverging mouth, formed by Cape

Horn on one ſide, and by the Cape of Good Hope on the other, through which it empties itſelf for ſix months into the Indian ocean, as will be ſhewn, all the properties of a directed fluid are diſcovered. With reſpect to its degree of inclination, computed in its diſtance from the pole to the ſouth ſea, by the Cape of Good Hope, I conceive it to be nearly the ſame as that of the river Amazon.

Let us now conſider the courſe of the polar fuſions produced by the action of the ſun upon the ice of the poles. Every year a general current proceeds from that which is heated, and as the ſun viſits them alternately, it follows, that there are two general and oppoſite currents which communicate to the ocean their movement of circulation, which are known in India by the name of eaſt and weſt, or of winter and ſummer monſoon.

This admitted, let us examine the fuſions of the ſouth pole, which is here ſhewn during its ſummer. Its general current is divided into two branches, one of which runs through the Atlantic ocean, and penetrates to its northern extremity. When this branch paſſes between the projecting part of Africa and of America, finding its channel narrowed, it forms on the coaſts two counter currents or eddies, which run in an oppoſite direction. One of theſe currents runs eaſt along the coaſt of Guinea to the fourth degree of ſouth latitude, according to Dampier. The other returns from Cape St. Auguſtin, and runs S. W. along the coaſt of Brazil to the ſtraights of Le Maire incluſively. This effect is the reſult of a common hydraulic law, viz. That whenever a ſtream paſſes from a broad to a narrow paſſage, it forms on its borders two counter currents. This may be verified in every brook; at the paſſage of water through arches, &c. Thus the tides ſet to the eaſt along the coaſt of Guinea, and to the S. W. along the coaſt of Brazil, during the ſummer of the ſouth pole. But in the middle of the Atlantic ocean, and beyond the narrows of the two continents, it ſets to the north, in its whole extent, and proceeds to the northern extremity of Europe and of America, bringing us twice a day along our coaſts the ſouthern tides, which are the ſemi-diurnal effuſions of the hemiſpheres or two ſides of the ſouth pole.

The other branch, which leaves the ſouth pole, takes to the weſtward of Cape Horn, mixes with the South ſea, produces the eaſtern monſoon in the Indian ſeas, which arrives in India during our winter; and having circumflowed the world to the weſtward, comes from the eaſt, and unites itſelf by the Cape of Good Hope, to the general current which runs into the Atlantic ocean. This general current of the ſouth pole, with its two branches, its counter currents and tides, may be followed in the plate* by the arrows, which ſhew its direct, oblique, and retrograde motions.

Six months after, that is, in our ſummer, beginning towards the end of March, when the ſun is on the Line, leaving the ſouth pole, and nearing the north pole, theſe ſouthern fuſions are checked. Then our pole begins to give, and the currents of the ocean change in all latitudes. The general current of the ocean then proceeds from our pole, and divides itſelf, like the ſouthern current, into two branches. The firſt of theſe branches proceeds from the ſtraights of Waigats, from Hudſon's Bay, &c. which then ſtream through certain narrows, with the velocity of a ſluice, and produce, in the north, tides which come from the north, the eaſt, and the weſt, to the great ſurprize of Linſchoten, Ellis, and other navigators, who were accuſtomed to ſee them come from the ſouth upon the European ſhores. This current, formed by the fuſion of the ice of great part of the north, and of America, Europe, and Aſia, which have then near ſix thouſand leagues in circumference, deſcends by the Atlantic ocean, croſſes the Line, and finding itſelf again ſtraightened in the narrows of Guinea and Brazil, forms on theſe two coaſts lateral counter currents, which return north, ſimilar to thoſe formed ſix months before by the current of the ſouth pole, which returned to the ſouthward. Theſe counter currents give us, upon the ſhores of Europe, the tides which always ſeem to come directly from the ſouth, though they actually then originate in the north.

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* Plate I.

The branch which produces theſe, then continues towards the ſouth, doubles the Cape of Good Hope, takes its courſe towards the eaſt, forms in India the weſtern monſoon, and having gone round the globe as far as the South ſea, it paſſes Cape Horn, returns along the coaſts of Brazil, and produces a current there, which ends at Cape St. Auguſtine, oppoſite to the parent current from the north. The other branch, which during our ſummer comes from the north, on the other ſide of our hemiſphere, empties itſelf by the northern ſtraights, between the eaſtern extremity of Aſia, and the weſtern extremity of America. It there falls into the ſouth ſea, where it joins the firſt branch, which, as we have obſerved, then cauſes the weſtern monſoon in thoſe ſeas. But this branch, by the northern ſtraights, receives much leſs of the polar fuſions than that of the Atlantic ocean, becauſe, the deep bays which are at the ſource of this current, and the form of theſe ſources, which ſpirally ſurround the pole, receive, as we have ſaid, the greateſt part of the polar fuſions to the northward, and throws them into the Atlantic ocean.

Thus the ocean, twice a year, travels round the globe in oppoſite ſpirals, alternately flowing from each pole, and may be ſaid to deſcribe upon the earth the ſame route which the ſun does in the heavens.

I think I may affirm this theory to be ſo clear, as to throw light on a multitude of difficulties which eternally darken the relation of Voyagers. Froger, for inſtance, ſays, that in the Brazils the currents go towards the ſun, that is, to the north when in the northern ſigns, and to the ſouth when in the ſouthern ſigns.

This

This verſatile effect cannot be accounted for by the preſſure or attraction of the ſun or moon between the tropics, as theſe planets never go beyond, and always in the ſame direction, that is, from eaſt to weſt; but the reaſon is, that when the current of the Brazils goes to the ſouth in our winter, it in fact is the counter current of the general current iſſuing from the ſouth pole, which then goes north. And when this Brazil current goes north in our ſummer, it is the laſt of the ſame current returning by Cape Horn. The ſame thing does not happen in the gulph of Guinea, which is oppoſite, and runs conſtantly to the eaſt, though exactly in the ſame ſituation; for in our winter this current in the gulph of Guinea is the laſt of the general current in the ſouth pole, which returns by the Cape of Good Hope, and runs north, in that ſeaſon, along the ſhores of Africa, from the 30th degree to the 4th degree of ſouth latitude, according to Dampier. But this termination of the general current which ſets north, and which when in 4 degrees ſouth goes to the eaſtward to join the general current again, does not get into the gulph of Guinea, from its great depth; ſo, that in that part alone the ſea always ſets to the eaſt, according to the obſervation of all African navigators.

I ſhall ſupport the principles of this theory, with facts atteſted by the moſt eſteemed mariners. Dampier ſpeaks as follows, on the currents of the ocean, in his Treatiſe of Winds.*

"However it is certain, that every where "the currents change their courſe at certain "times of the year. In the Eaſt Indies they "ſet from eaſt to weſt during a fixed part of "the year, and from weſt to eaſt during the "reſt of it. In the Weſt Indies, and in Guinea, they only change towards the full. But "this muſt be underſtood with reference to "the part of the ſea which is not diſtant from "the coaſt, not but that there are currents of "extraordinary power in the great ocean "which do not follow theſe rules, but this is "not uſual.

"On the coaſt of Guinea the current ſets "eaſt, except at the full or thereabouts; but "to the ſouthward of the Line it ſets with the "ſoutherly winds to the north, except about "the full.

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* Page 386, 387.

"To the eaſtward of the Cape of Good "Hope, from the 30th to the 24th degree of "ſouth latitude, the current runs eaſt, from "the month of May to October, and the wind "is then W. S. W. or S. W. But from October to May, when the wind is between the "E. N. E. and E. S. E. the current goes to the "weſtward, and this is felt from five or ſix "leagues from the ſhore to the diſtance of fifty "leagues, for within five or ſix leagues there is "no ſtream but a tide, and beyond fifty leagues "the current ceaſes, or is imperceptible.

"On the ſhores of India, to the northward "of the Line, the current follows the monſoon. "But it does not exactly change with it, ſometimes not for three weeks, or more, after which "it does not alter till the contrary monſoon is "eſtabliſhed. For inſtance, the weſtern monſoon begins in the middle of April, but the current does not change till the beginning of May; "and the eaſtern monſoon begins towards the "middle of September, but the current does "not change till the month of October."

Dampier ſeems to attribute the cauſe of theſe currents to winds, which he calls monſoons. It is not my intention here to conſider the cauſe of the atmoſpheric revolutions, which I believe to proceed from the poles, whoſe atmoſpheres are more or leſs dilated in ſummer and winter, and whoſe revolutions muſt *precede* thoſe of the ocean. I ſhall only notice the ſtages of the weſtern current, which only arrives in India during the month of May, to prove that it is the ſame which leaves our pole in the month of March, and which reaches different latitudes in India, in times proportioned to the diſtance from whence it took its departure.

This current, then, arrives towards the month of April at the Cape of Good Hope, and renders the paſſage round the Cape ſo difficult to ſhips returning from India in the ſummer. I ſhall again depend upon Dampier, in his Voyage round the World,* for this fact. He ſays, in his return from India to Europe,

"We were loſing the ſeaſon for doubling "the Cape, which could only return in October "or November, for it was now the end of "March. And it is never the cuſtom to ap-"proach the Cape after the 10th of May."

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* Vol. II. p. 14.

The Dutch India Company, indeed, never permit their ſhips to remain there after the month of March, becauſe then the weſterly winds ſet in with a weſterly ſwell, which throw the ſhips in ſhore; from which it appears, that the current, coming from the weſtward in doubling the Cape, arrives there about the month of April.

By this paſſage of Dampier's, we find the weſtern current arrived upon the Indian ſhores about Mid-May. Another authority will prove, that it reached Tinian about Mid-June, which is conſiderably to the eaſtward, and which I find in the Voyage of Lord Anſon,* who, ſpeaking of Tinian, ſays,

" The only anchoring for large ſhips is on the " S. W. ſide of the iſland. The bottom of this " roadſted is full of ſharp coral rocks. It is " dangerous to anchor from the middle of June " to the middle of October, which is the ſeaſon " of the weſtern monſoon; and the danger is " ſtill increaſed by the extraordinary rapidity of " the tides, which, between Tinian and Agnigan, ſet to the S.W. During the other

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* Chap. 14. Anno 1742.

" eight months of the year the weather is re-
" gular."

It is here to be obſerved, that during the monſoon, when the current comes from the weſtward, the tide ſets the contrary way between theſe two iſlands, which confirms what I have ſaid, that the tides are generally but the counter currents, or reaction of general currents confined by ſtraights.

Thus it is ſeen, that the current which leaves our pole in March, reaches the Cape of Good Hope in April, the coaſts of India in Mid-May, the iſland of Tinian in Mid-June, and deſcribes round the globe the ſpiral I have before indicated. Its velocity might be computed by the time it takes in getting to each of theſe places, and to others in other latitudes, till it arrives at Cape Horn, where it inclines to the north, as far as Cape St. Auguſtine, and there, towards the end of July, meets the general Atlantic current. But the detail of ſo many curious circumſtances would lead me too far.

The general current of the Indian ſeas, which, as I have ſaid, runs ſix months to the eaſtward, and ſix months to the weſtward, cannot be attributed to the attraction or preſſure of the ſun or moon between the tropics, for theſe planets always keep the ſame courſe, and their influence is the ſame at all times during their ſtay in the torrid zone, which they never quit. Beſides, if their power were the cauſe when the ſun were to the northward of the Line, the weſtward monſoon ought to be felt in India in March, the ſun being nearly then in the zenith of the Indian ſeas; and yet it only begins there ſix weeks after, that is, in May; and on the contrary when the ſun is to the ſouthward of the Line, and the furtheſt from the Indian ſeas, the monſoon arrives ſhortly after the September equinox, that is, in the month of October.

Hence it appears, that theſe revolutions of the Indian ocean have not their origin under the equator, but at the poles, and that the March monſoon, which comes from the north by the weſt, takes ſix weeks before it is felt in India, from the great circuit it is obliged to make round the Cape of Good Hope, and that the ſouthern monſoon, in the month of September, gets there much ſooner, becauſe it has no circuit to make; and laſtly, that the period of theſe verſatile revolutions commences exactly at the equinox, at the moment when the ſun forſakes one pole to vivify the other.

It is then evident, that the ſemi-annual and alternate currents of the Indian ſea, owe their exiſtence to the ſemi-annual and alternate fuſions of the poles, and that their directions from eaſt to weſt, and from weſt to eaſt, are produced by the projection of the Aſiatic continent.

The Atlantic ocean has equally two ſemi-annual and alternate currents, which have the ſame origin, but with a natural direction from north to ſouth, and from ſouth to north, though rather inclined to the eaſt and to the weſt, by the poſition of the Atlantic canal itſelf. Our navigators only allow of one perpetual current, which always ſets from the ſouthward to the northward, in our hemiſphere. They are led into this error by the ſet of the tides, which always go north upon our coaſt, and on that of the Bahama's, and by our ſyſtem of aſtronomy, which attributes all the movements of the ſea to the action of the moon within the tropics.

What error does one prejudice occaſion in the elements of ſcience? It ſo totally warps the cleareſt underſtanding, as to make it pervert the ſimpleſt evidence, and for ages reject the experience of every ſucceeding year!

From many voyages, and chiefly thoſe made with ſo much judgment and perſpicuity by Capt. Cook, I have collected a number of nautic obſervations, which aſcertain that the currents of the Atlantic are alternate and ſemi-annual, like thoſe in the Indian ocean; and yet even the perſons who relate them, full of the prejudice that the action of the moon alone between the tropics gives motion to the ſea, have not been able to conclude any other, than that their motions are irregular and inexplicable. Had they confided in their experience, which taught them that the currents changed twice a year,—that in the Indian ocean, for ſix months they ran with the moon, and for ſix months againſt her,—that in the Atlantic, they were ſubject to directions independant of the moon's orbit,—that they were much more rapid near the poles, than they were immediately under the moon's preſſure in the tropics;—and laſtly, that melted by the ſun, they were annually poured from pole to pole, they would have concluded that the cauſes of ſuch change proceeded from the ſummer and winter of each hemiſphere, and have diſſipated the cloud of errors with which our pretended knowledge has veiled the operations of nature.

Theſe nautic obſervations, are, in my opinion,

nion, deciſive, having been made by enlightened followers of the preſent ſyſtem, which they abſolutely deſtroy, while they eſtabliſh the truth of my theory,—yet I ſhall quote two facts, more curious, more authentic, and more impartial, inaſmuch as they are related by men, who, not belonging to the ſea, were not ſubject to its ſyſtems or its prejudices. The one is evidenced by the inhabitants of a whole nation, and the other is found among the moſt awful of naval records, and both confirm one of the moſt pleaſing harmonies in the hiſtory of vegetable nature, the elements of which I have given when treating on the emigration of plants.*

By the firſt of theſe obſervations, we ſhall prove that the Atlantic current actually comes from the ſouth and ſets to the north, as believed by our mariners, but only in winter. It receives this direction by the fuſion of the ice at the ſouth pole, whoſe ſtream during our winter runs to the northward, and not, according to our aſtronomy, by the action of the moon between the tropics; for, at that very ſeaſon, the navigators in the ſouthern hemiſphere, beyond the tropics, perceived the current from the ſouth, which certainly had not

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* Vol. p.

been the caſe, were it the effect of the moon preſſing on the equator; for on this hypotheſis it would run the contrary way in the ſouthern hemiſphere. But that is not the caſe, as I can prove by the Journals of Abel Taſman, Dampier, Froger, Cook, &c. who all, while beyond the tropics, in the ſouthern hemiſphere, met with the current from the ſouth, but during our winter only.

By the ſecond of theſe obſervations, we ſhall prove that the Atlantic current comes from the north, and ſets to the ſouth, contrary to the opinion of mariners, but only during our ſummer. It therefore proceeds immediately from the fuſion of the ice at the north pole, which in our ſummer diſſolves and ſtreams towards the ſouth; and this equatorial direction clearly deſtroys the ſuppoſed effect of the action of the moon between the tropics, which, in the opinion of our aſtronomers, is an expanſion of the ocean from the equator towards the poles.

The firſt of theſe obſervations is given us by Mr. Thomas Pennant, a learned Engliſh naturaliſt. It is taken from his Voyage in 1772 to the Hebrides.*

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* Printed at Geneva in 1785, in a collection of Voyages to the Highlands and Hebrides of Scotland. Paris chez Noyon. 2 Vol. in 8vo. Vol. I. p. 216, 217.

"But," ſays this enlightened traveller, "a "circumſtance more authentic and aſtoniſhing "is, that here (in the iſle of Ilay) and on the "whole coaſt of the Hebrides, are found the "ſeeds of plants the growth of Jamaica, and "its neighbouring iſlands, ſuch as the dolichos "urens, guilandina bonduc, bonducetta, mimoſa ſcadens of Linnæus. Theſe ſeeds, "here called Molucca beans, grow on the "borders of rivers in Jamaica, and thence "borne by the currents and the weſterly "winds, which reign for two thirds of the "year in the Atlantic, are conducted to the "ſhores of the Hebrides. The ſame ſometimes "happens to turtle, which are taken alive on "this coaſt, and this is paſt doubt, ſince a part "of the Tilbury man of war's maſt,* *burnt* "*near Jamaica,* was found on the coaſt of "Scotland."

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* The Tilbury was not burnt, or loſt near Jamaica She was wrecked on the Iſland of Cape Breton, in Gabarus bay, not far to the weſtward of Louiſburgh. However this will but ſtrengthen St Pierre's argument, as it ſhews that the current which carries the ſeeds, &c. from Jamaica to the north and eaſt is the gulph ſtream, and actually picks up the wreck of a ſhip loſt near Louiſburgh. The wreck was carried to ſea by the ebb, and the prevailing N. W. winds, and fell into the current ſetting to the N. E. from the Weſt Indies to the Hebrides. Is it not, then,

Mr. Pennant has omitted to mention the time of the year when theſe ſeeds and turtle land on the weſtern coaſt of Scotland. Theſe omiſſions of date are a great error, and very common with moſt Voyagers, who frequently neglect to note the time of their own obſervations; and yet it is only by dates that the harmonies of nature can be compared. What, then, muſt we think of the taſte of our compiliers of Journals, who curtail them as tedious and uſeleſs parts? It is, however, in this caſe, eaſily aſcertained, that the ſeeds of the Jamaica rivers, and the turtle arrive, during the winter, on the weſtern coaſts of the Hebrides and Orkneys, being driven there according to Mr. Pennant, by the winds and currents from the weſt, which, he ſays, reign there for two thirds of the year; and it is known that the weſterly winds blow there the whole winter, which is confirmed in this account by his own teſtimony, and by that of others in the ſame collection. But, after all, it is not the winds at weſt which drive the ſeeds and turtle ſo far from Jamaica to the northward.

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then, reaſonable to ſuppoſe the banks of Newfoundland, formed in time by the depoſit of the gulph ſtream, and, of the ebb from the neighbouring ſhores and rivers of America? **Translator's Note.**

Winds can have no hold of bodies level with the ſea, and certainly thoſe at weſt cannot impel to the north. Nor could the currents from the weſt produce this effect, for they would carry to the eaſt, and as Jamaica lies in 18 degrees north, theſe ſeeds and turtle would land in Africa in the ſame latitude, and not ſo high as 59 degrees north, among the Hebrides and Orkneys, where they actually are depoſited. The current, then, which conducts them, ſets directly to the north, rather inclining to the eaſt, preciſely with the Atlantic canal in theſe parts. Thus the important obſervations of the inhabitants of Scotland, on the ſubject of Jamaica ſeeds and turtle, and of the wreck of the Tilbury's maſts, thrown on their coaſt, proves, beyond doubt, that the Atlantic current comes from the ſouth and ſets to the northward, as believed by mariners, but it has that direction only during the winter; for we are about to prove, by another not leſs curious obſervation, that during the ſummer, and in the ſame latitudes, the Atlantic current comes from the north and ſets to the ſouth, in oppoſition to the ſuppoſed action of the moon between the tropics, and to the opinion of mariners, or rather to the ſentiments of thoſe who knew not where to pin their faith on this ſubject.

We have already adduced the teſtimony of the moſt celebrated navigators of the north, who unanimouſly atteſt that the Atlantic current comes from the north, and ſets to the ſouth in ſummer, at its northern extremity, ſuch as thoſe of Ellis, Barents, Linſchoten, &c. who, having navigated in ſummer in the vicinity of the arctic polar circle, affirm that the currents and even the tides are directed towards the ſouth, and deſcend from the north, or at furtheſt from the N. W. or N. E. according to the aſpect of the inlets into which they penetrated. We have further, in ſupport of this important fact, produced the evidence of navigators in North America, cited by Denis, Governor of Canada, who affirm that the currents from the north every year, during the ſummer, bring with them to the ſouthward long tracts of floating ice, of conſiderable depth and elevation, which frequently ground on the banks of Newfoundland. And laſtly, we have named the obſervation of Chriſtopher Columbus, who, in a much more ſoutherly latitude, even in the vicinity of the tropic of Cancer, in the month of September, felt that the middle of the Atlantic current ſets to the ſouthward, and therefore comes from the north. We might add to theſe authorities, thoſe of a great number of other navigators, who only attended to the drift of their ſhips, and have obſerved the ſet of this northern current without daring to avow it; or to oppoſe their perſonal experience to an eſtabliſhed aſtronomical ſyſtem.

But not to omit any thing eſſential on a ſubject ſo intereſting to navigation, and to raiſe all doubt on the exiſtence of this northern ſummer current, we ſhall notice one well eſtabliſhed hiſtorical fact. The obſervation is not liable to cavil, becauſe it is handed to us without any intent of ſupporting a ſyſtem, and by a traveller, who was neither navigator or naturaliſt, and who only drew ſuch concluſions as affected his property; I mean that of Sonchu de Rennefort, Secretary to the Sovereign Council of Madagaſcar, who left the Azores on the 20th June 1666, on his return to Europe.*

"From the 40th to the 43d degree," he ſays, "we fell in with broken maſts, yards, and "tops of ſhips, which made us conclude there "had been ſome dreadful wreck. The ſtriking "on theſe was much dreaded on board La

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* Hiſtory of the Eaſt Indies, b. 3. ch. 5.

“ Vierge de bon Port, an old veſſel, rotten, and “ eaſily ſtove. It has ſince been known, that “ this havock was the conſequence of an action fought between the French and Dutch “ on one ſide, and the Engliſh on the other, “ which it had been fortunate for us to have “ been earlier apprized of.”

Rennefort’s ſhip, not knowing of the war between France and England, was ſo unfortunate as to be captured and ſunk by an Engliſh frigate, near Guernſey, the eighteenth day after this obſervation, that is, on the 10th of July.

This dreadful wreck, covering the ſea for the ſpace of three degrees, or of ſeventy-five leagues, proceeded from the moſt obſtinate combat which has yet been known on that element, fought by the Engliſh on one ſide, and the Dutch on the other. It began the 11th of June, and continued four days. The Britiſh fleet was compoſed of eighty-five ſhips of war, and the Dutch, commanded by Ruyter, of ninety ſail. Nearly twenty-one thouſand men, and four thouſand five hundred cannon, were engaged on each ſide. Of the Engliſh, twenty-three ſhips periſhed, moſt of whom were burnt or ſunk. Of the Dutch, only four, but almoſt every ſhip loſt all, or nearly all, her maſts. About nine thouſand men fell. The hiſtorians of each nation, as uſual, carried the glory of their reſpective fleets to immortality,—but it was too evident, that nine thouſand mutilated and half-conſumed bodies, abandoned to ſharks and to ſea-dogs, afforded the monſters of the ocean an example of ferocity only to be met with in human nature, and the prodigious number of maſts and yards, mixed with red and white croſſes, were borne as leſſons to Barbarians, and taught them how nations, ſtiling themſelves Chriſtian, arrange their mutual differences.

This wreck was certainly carried beyond the Azores. It is probable, that during that ſeaſon a conſiderable portion floated to the ſhores and iſlands on the weſtern ſide of Africa. It was preciſely for the Slave Trade in Africa, that England and Holland were waging war. Theſe powers had in the preceding year commenced hoſtilities on the coaſt of Guinea, and in the Cape de Verd Iſlands, to the ruin of the inhabitants. Let us, then, imagine this wreck of the battle of Oſtend, carried beyond the Cape de Verd, and near the iſland of St. John's, ſo little frequented by Europeans, that the Portugueze name them brava, or ſavages. Its virtuous and hoſpitable inhabitants, according to the Engliſhman Roberts, who experienced their tender care, are ſo modeſt, that they conſider Men of Colour as ſubmitted, by the expreſs will of the Deity, to the power of the Whites. They are confirmed in this idea, by conſidering the ſcale of European commerce, one branch of which offers every wealth to Europe, whilſt the other, laden with evils, preſſes hard upon unfortunate Africa!—But when, from the ſummit of their rocks, under their cocoa and Banana ſhade, they diſcovered along their peaceable ſhores this horrid ſucceſſion of maſts, yards, galleries, poops, figures half burned, ſtained with human gore, and mixed with European colours, they beheld the ſcourge of Africa riſing in its turn, and preſſing hard on Europe. In this reaction of calamity they doubtleſs acknowledged, that Eternal Juſtice is equally diſpenſed to the oppreſſed and the oppreſſor.

A King of France, it is ſaid, cauſed the bodies of criminals to be thrown into the river, with this gloomy label, "*Let the King's Juſtice* "*paſs.*"—The Chineſe and Japoneſe have the ſame mode of puniſhment for pirates infecting the navigation of their rivers. And thus the wrecks of theſe ſhips of war, which had ſo often ſpread terror on the Atlantic ocean, were borne by its currents, and their vaſt ribs, purpled with human blood, and now the ſport of the African ſea, ſpoke much clearer than labels, to its oppreſſed inhabitants, and ſaid, or ſeemed to ſay, "*O Blacks, behold, as it paſſes,* "*the glory of Whites, and the juſtice of God!*"

It were a calculation worthy, I will not ſay, of modern politicians, who eſteem nothing in the creation greater than gold and power; but of the friends of human nature to inquire, if the Slave Trade has not cauſed as many evils to Europe as to Africa, and what are the advantages it has produced to each?

The firſt thing to be thrown in the ſcale, on the ſide of Africa, are the wars which its nations enter into, to procure ſlaves for ſale to Europeans. The rigorous deſpotiſm of its Kings, who, to effect this purpoſe, deliver up their own ſubjects. The unnatural character of theſe ſubjects, who, in the practice, carry to market their wives and children. The greater part of the maritime ſtates of Africa, rendered deſert by the emigration of their inhabitants, ſold to ſlavery. The mortality of great numbers of theſe wretches, dying on their paſſage to the iſlands, the conſequence of bad food, of puniſhment, of exceſſive labour, of ſcarcity of proviſions, of miſery, ſorrow, and deſpair. There, doubtleſs, are tears and blood enough ſhed by Africa; but the balance of misfortune is at leaſt equalled in Europe, if we conſider the navigation itſelf of Africa, whoſe unwholeſome climate carries off the whole crew of our ſhips, and the garriſons in our ſettlements. The dyſenteries, the ſcurvy, the putrid fevers, and particularly that of Guinea, which in three days deſtroys the moſt athletic men.—Add to theſe phyſical ills the moral malady of ſlavery, which in our iſlands deſtroys the firſt feelings of humanity; for wherever ſlaves exiſt, tyrants are produced.—Add the effect of this depravity in morals on Europe.—Add to the ills of this part of the world, the reſources of rural labour withdrawn in the Weſt Indies from our merchants and farmers, great numbers of whom are idle with us, from the want of employ and poſſeſſions.—Add the wars which the Slave Trade occaſion among the maritime powers of Europe, their factories taken and retaken, their naval fights, ſweeping away nine thouſand men at once, without including thoſe maimed for the reſt of their days,—wars, which like the plague, are communicated to interior Europe by their alliances, and to the reſt of the world by their commerce.

Theſe things conſidered, it will be admitted that the balance of European evils is fully equal to that of Africa. With reſpect to the balance of profit, it is reduced on each ſide to ſmall account. We cannot in conſcience eſtimate as gain, the money produced to the Africans by the ſale of their fellow creatures,—nor our iron ſabres, with which they cripple each other,—nor our bad muſkets, which fracture their ſculls,—nor our ſpirits, which ſap their vigour and deſtroy their intellects. To them the whole is reduced to a few bells and glaſſes. The advantages to Europe are ſugar, coffee, and cotton, produced in the Weſt Indies by the drudgery of ſlaves; but thoſe unimproved and imperfect productions cannot be compared to the manufacture and produce of all kinds, which free, happy, and intelligent European cultivators would raiſe in thoſe plantations.

It appears to me, that if this eſtimate of weighty evils and inſignificant gains were weighed by the maritime and Chriſtian powers of Europe, they would at length acknowledge that it is not ſufficient to forbid ſlavery at home, as a means of rendering their ſubjects happy and induſtrious, but that they muſt equally forbid ſlavery in their colonies, as the foundation of happineſs to their ſubjects, to that of human nature, and to the honor of their religion.

But to return.—This wreck ſcattered over ſeventy-five leagues of ſea, came from twelve miles north-eaſt of Oſtend, where the action took place, and was carried as far as the Azores, which Rennefort's ſhip left when ſhe fell in with it. Oſtend is in about 51 deg. north, and the Azores greatly to the weſtward, in about 40 degrees. The firſt of this wreck took its departure from the north-eaſt of Oſtend on the 11th of June, the time of the firſt part of the action, according to Ruyter's letter, and the Hiſtory of France; and it was ſeen near the Azores at lateſt on the 20th of the ſame month, as appears by Rennefort's account, though without daily date. Thus the currents of the north had carried it in nine days upwards of 275 leagues ſouth, which is conſiderably more than 34 leagues a day or 4¼ miles per hour.

It was clearly not the wind which drove this wreck to the S. W. with ſuch rapidity. The winds which then prevailed were againſt it. Rennefort's ſhip, meeting it, had S. W. winds, and Ruyter, in his letter, only mentions S. W. winds, which blew during the action. Beſides, as already aſked, what effect can the winds have on a body level with the ſea? Nor could it be carried ſouth by our tides, which ſet north on the coaſts. It was then a direct current from the north which drove it to the ſouth, in oppoſition even to the tides, and a little to the weſtward, by the poſition of the Atlantic canal itſelf. This current, then, ſets to the ſouthward in ſummer, in oppoſition to the ſuppoſed action of the moon between the tropics, and owes its impulſe at that time to the fuſion of the polar ice.

Theſe two authentic obſervations alſo prove, that the iſlands are placed at the extremity of currents, as before obſerved.

Linſchoten, who had lived in the Hebrides, obſerves, that the greater number of wrecks on the Atlantic ocean are thrown on their coaſts. The ſame takes place on the coaſts of Bermuda and Barbadoes. Floating bodies are carried to prodigious diſtances, regularly and alternately, like the currents of the ocean itſelf. Thus the ſeeds of Jamaica, in winter, are carried by the currents of the ſouth pole to the Orkneys, more than 1060 leagues from ſouth to north, and more than 1800 leagues in traverſe diſtance; and, doubtleſs, the ſeeds of the Orkney water plants are, in ſummer, carried to the coaſts of Jamaica, by the current from the north pole. The ſame relation muſt exiſt between the vegetable of Holland and the Azores. I am not acquainted with any ſeeds of the Jamaica rivers, but I am very certain they have the ſame nautic character which diſtinguiſhes all the water plants I have as yet examined. We have, therefore, in this inſtance, another proof of the vegetable harmony of nature, in the emigration of plants. This law may alſo be applied to the emigration of fiſh, making ſuch long traverſes in the open ſea, and, I apprehend, guided by the floating ſeeds of water plants, for which they have in all countries a decided preference, and which nature has ſcattered on its ſhores for their eſpecial nouriſhment.

I conceive, by means of the regular currents of the ſea, a correſpondence might be eſtabliſhed, void of expence, throughout the maritime parts of the world. Perhaps by this means the vaſt foreſts in the north of America and of Europe, in great meaſure compoſed of pines, rotting, and without advantage to their own ſoil, or to mankind, might be cleared. They ſhould in the ſummer, in rafts well ſecured, be committed firſt to the tides of the rivers, then to the currents of the ſea, which, at leaſt, would bring them to our latitudes, ſo generally in want of timber; as the courſe of the Rhine brings down every year to Holland, a prodigious fall of oaks from the the foreſts of Germany. The wreck of the battle of Oſtend, carried ſo rapidly to the Azores, opens an extent of reſources beſtowed upon us by nature.

Geography alſo may reap great advantages by it. Chriſtopher Columbus owes the diſcovery of America to the effect of theſe currents. A mere reed, of an unknown ſpecies, accidently thrown on the ſhores of the Azores, determined this great man in his belief of a weſtern continent. He intended making further uſe of the currents on his return from his firſt voyage; for, being nearly loſt in a gale of wind in the middle of the Atlantic ocean, without means of informing Europe (which had long deſpiſed his ſervices and his knowledge), that at length he had diſcovered a new world; he encloſed the narrative of his voyage in a caſk, which he committed to the ocean, truſting that at ſome period it would reach the ſhore. A mere glaſs bottle might for ages preſerve the relation on the ſurface of the ſea, and carry it more than once from pole to pole.

It is not to opinionated and unjuſt perſons, who deny in nature what they cannot diſcover in their cloſets, that I wiſh to preſent ſuch maritime harmonies. It is to unfortunate ſeamen that I look for my moſt laſting and honourable recompenſe. Perhaps, at ſome future day, wrecked on a deſert iſle, they may commiſſion the currents of the ſea to convey the information to ſome habitable coaſt, and require its aſſiſtance.

After the facts I have ſtated, there can be no doubt that the Indian and Atlantic ocean have their ſources from the ſemi-annual and alternate fuſion of the ice at the ſouth and north pole; and that they have ſemi-annual and alternate currents, in perfect uniſon with the ſummer and winter of each pole. Theſe currents, it will be allowed, have more velocity than the bodies floating on their ſurface. During the equinox a ſudden retrograde impulſe takes place in the whole maſs of waters, which during thoſe periods is manifeſted in the general agitation of the ocean, in all latitudes. This revolution, total and almoſt immediate, cannot be effected by the attraction of the moon or the ſun, which always go the ſame way, and are conſtantly within the tropics. But, as I have often aſſerted, it is the effect of the heat of the ſun which at this ſeaſon of the year paſſes almoſt ſuddenly from one pole to the other, diſſolves the frozen ocean which ſurrounds it ; gives, by the fuſion of the ice, new ſources to the ocean, oppoſite directions to its currents, and reverſes the accuſtomed equilibrium of its waters.

Still leſs can the cauſe of the tides be attributed to the action of the moon and ſun upon the equator ; for were that the caſe, they muſt be ſtronger between the tropics, near the primary cauſe of their motion, than any where elſe, which is not the fact. Dampier ſpeaks as follows, of the Indian tides near the equator:

“ From Cape Blanc, on the coaſt of the “ South ſea, in latitude 3° to the 30° degree “ of ſouth latitude, the ſea riſes and falls but “ 1½ or 2 feet. The tides in the Indian ſeas “ riſe but little, and are not ſo regular as in “ Europe.” He again ſays, “ They at moſt are “ of four or five feet.” He afterwards relates that the higheſt tides he felt on the coaſt of New Holland, only took place the third day after the new or full moon.

The weakneſs and conſiderable delay of the tides between the tropics, prove moſt clearly that the impulſe of their motion is not under the equator, for were it there, the tides would be moſt rapid on the coaſts of India, which are in its vicinity, and parallel to it. But their origin is near the poles, where they actually riſe from twenty to twenty-five feet; for inſtance, in the ſtraights of Magellan, according to Sir J. Narborough; and by Ellis's report, they have an equal riſe at the entrance of Hudſon's Bay.

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* Treatiſe of Winds, p. 318.

Let us recapitulate.—The tides are the ſemi-diurnal fuſions of the ice at one pole, and the general currents of the ſea are its ſemi-annual fuſions. There are two oppoſite general currents in the year, becauſe in that period the ſun ſucceſſively heats the ſouthern and the northern hemiſphere. Every day, that is, every twenty-four hours, there are two tides, becauſe the ſun during that time alternately heats the eaſtern and the weſtern ſide of the melting pole. It is an effect ſimilar to that we ſee produced in lakes near mountains of ice, which have a flood and an ebb, but during the day only. But there is no doubt, that if the ſun during the night heated the oppoſite ſide of the mountains, another flood and another ebb would be produced in the lakes, and therefore, as in the ocean, two regular tides in the twenty-four hours.

The daily difference in the arrival of the tides, which is of nearly twenty-four minutes between each, is the conſequence of the cupola of ice in fuſion diminiſhing every day in diameter. Therefore the ſeat of the tides is every day further removed from our coaſts. If, according to Bouguer, the power of the tides is ſuch, that in ſummer the evening tides are ſtrongeſt, it is becauſe they proceed from the diurnal fuſion of our pole, taking place during the day of a warm ſeaſon. If in that ſeaſon they are weaker in the evening, it is becauſe they are the nocturnal fuſions which come from the oppoſite ſide of the pole, and diſcharge themſelves into the ſources of the Atlantic, in a ſpiral and in a leſs quantity. If, on the contrary, in the courſe of ſix months, the ſtrongeſt tides, that is thoſe of the evening, become the weakeſt, and the weakeſt, that is thoſe of the morning, become the ſtrongeſt, it is becauſe they proceed from the action of the ſun on the ſouth pole, and the cauſe being reverſed, the effects muſt be equally ſo. If the tides are ſtrongeſt a day and a half or two days after the full moon, it is becauſe that planet increaſes by its warmth the polar fuſions, and therefore the quantity of water in the ocean. The moon not only poſſeſſes warmth enough to evaporate water, as lately obſerved at Rome and Paris, but it alſo melts ice, which is noticed by Pliny, on the obſervations of the ancients.—“ The moon occaſions a thaw, diſ-“ ſolving all ice and froſt by the moiſtneſs of “ its influence.”* Laſtly, if the tides riſe higher during the equinox than in the ſolſtice, it is, as we have before obſerved, becauſe, during the equinox, there is the greateſt poſſible volume of water in the ocean, the greateſt part of the ice of one pole being then melted, and that of the other pole then beginning to melt.

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* Nat. Hiſt. b. 2. ch. 101.

It muſt not be imagined that every tide is the polar fuſion of that day. It is the effect of that gradation of polar fuſions which arrive in ſucceſſion; ſo that the tide which this day reaches our coaſts, perhaps left the cupola ſix weeks ago, and its motion is kept up by thoſe which daily impel in the rear. Thus, in a row of balls ranged on a billiard table, the firſt which receives an impulſe communicates it to its neighbour, that to the next, and the laſt only is detached from the row, by the remains of its motion. But the harmony which ſubſiſts between the moſt diſtant effects of nature, cannot, but in this caſe, be the ſubject of admiration; for the morning and the evening tides takes place on our coaſts, as if they left the ſuperior and inferior parts of our hemiſphere the ſame day; and the ſummer tides are exactly oppoſite to the winter tides, as are the poles from whence they originate.

I could ſupport this new theory by a multitude of facts, and apply them to moſt of the nautic phænomena which have hitherto been conſidered as inexplicable. But my time, and the times, will not allow it. It is enough to have deduced the principal movements.—I have made way through this labyrinth, with a degree of labour which the reader will ſcarcely credit. I have given him the clue, I now preſent him with the thread. He will, doubtleſs, be able to unravel much further without my aid. I can aſſure him, that by enlightening himſelf with theſe principles, when reading voyages which have ſome exactneſs in the dates of their obſervation, ſuch as thoſe of Abel Taſman, Hugo Linſchoten, General Beaulieu, Froger, Fraſer, Dampier, Ellis, &c. he will perceive a new dawn breaking on parts of theſe journals, which are generally eſteemed unprofitable and obſcure.

If my time and my means had allowed me to throw all the light poſſible on this ſubject, I dare flatter myſelf I ſhould have made it infinitely more intereſting. I had ſhewn on two large ſolid globes, the two general currents of the ocean, in winter and ſummer, by arrows, expreſſive of the exact intervals between each tide, and their lateral counter currents in the narrows of all ſtraights, which produce on different ſhores the counter tides, ſemi-diurnal, diurnal, weekly, lunar, and ſemi-annual. Theſe counter tides had produced others in return at the ſtraights of thoſe iſlands, ſo that the ocean had appeared like a vaſt fluid, departing from each pole, and forming on the coaſts a multitude of counter currents and counter tides, the whole depending on the fuſion of a ſingle pole. I had employed for this purpoſe the moſt eſteemed maritime journals. It had evidently appeared that the bays of continents and even of iſlands are ſheltered from the general currents; and I had alſo ſhewn, that the poſition and direction of all rivers are placed with reference to theſe currents and tides of the ocean, in ſome places to accelerate them, and to retard them in others,—juſt as the courſe of rivulets and rivers is with reference to the current of their ſtreams, and for the ſame purpoſes.

I had gone ſtill further. In order to amend the barren ſtate of our geography, and to unite the varied graces of the ſeveral orders of nature, inſtead of arrows, I had made uſe of figures more analagous to the ſea, and I had added new proofs to the theory of polar fuſion, by giving many ſpecies of travelling fiſh, which during certain times of the year abandon themſelves to the currents, and paſs from one hemiſphere to the other. It is very certain that the principal point of union between the two poles is exactly in the narrows, between Guinea and Brazil, where we have obſerved the two great counter currrents were formed, and which return toward the poles. This is the rendezvous of fiſh travelling from the north and the ſouth pole. Herrings, whales, and mackarels, are found in profuſion on theſe coaſts during the ſummer. The northern whales were ſo plenty formerly in the Brazils, that, according to the relation of Voyagers, their fiſhery was farmed, and produced a great revenue to the King of Portugal. I do not know its preſent ſtate, perhaps the noiſe of European artillery has driven them from thoſe coaſts. Cod was alſo caught in great quantity, and known over all America, by the name of Brazil cod. On the other hand, by the narrative of the Dutchman Boſman, who has given us a very good account of Guinea, whales of the kind, called Nordt Capers, or Northern Privateers, abound on the coaſt of Guinea. He pretends they come there to produce their young. Artus has preſerved a liſt of travelling fiſh, which appear on that coaſt during the different months of the year; though very imperfect, yet the fiſh peculiar to each pole are found in it. In the month of April, or May, it is a kind of thornback, which ſwims on the ſurface of the ſea; in June and July a kind of herring, ſo numerous, that the negroes, by throwing among them a piece of lead, at the end of a long line beſet with hooks, always catch many at one draught. In the ſame months they catch many ſea lobſters, like thoſe, ſays Artus, caught in Norway. In September various kinds of mackarel arrive. There appears at the ſame time a kind of mullet, which, in contradiction to other fiſh, make towards any noiſe; the negroes employ this inſtinct to catch them;—they fix to a piece of wood beſet with hooks, a kind of bell, which making a noiſe attracts the fiſh, and endeavouring to bite the wood they are hooked. Thus munificent nature has ſupplied the negroes with food proportioned to their induſtry. This ſpecies of mullet, ſeems, by its inſtinct, deſtined to boiſterous ſeas and climates, ſince it only appears in the autumnal equinox during the revolution of the ſeaſons. But in the months of October and November, we are viſited by abundance of fiſh, whoſe names and cuſtoms are unknown in Europe, and which appear natives of the ſouth pole, whoſe currents are then in action. Such are the ſea pike, or becune, whoſe teeth are very ſharp, and bite very dangerous.—A kind of ſalmon with white fleſh, of remarkably good taſte; another called the ſea-ſtar.—A kind of ſea-dog, with a large head, and a jaw like a warming pan; it is marked on the back with a croſs, and is ſo large that a ſingle fiſh loads two or three boats. In December numbers of the corfofedo, or moons, arrive, which are alſo ſeen in June. The corfofedo ſeems to regulate his march with the ſolſtice. He is equally broad and long, and is caught by faſtening a piece of ſugar-cane to a hook. The taſte of this fiſh for ſugar-cane, is a further proof of the harmony exiſting between fiſh and vegetables. Laſtly, in the months of January, February, and March, the coaſt of Guinea exhibits a ſpecies of ſmall fiſh with large eyes, which Artus thinks are the oculus, or piſcis oculatus of Pliny. This fiſh is alſo an inhabitant of the troubled equinoctial ſeas, for he leaps and moves with conſiderable noiſe.

If my time had allowed, I had extended theſe elementary harmonies to various inhabitants in the department of the ſea. We ſhould, for inſtance, have ſeen the cauſe of the alternate paſſage of turtle, which go every year for ſix months to certain iſlands, and which ſix months after are found in iſlands ſeven or eight hundred leagues diſtant, without its having as yet been comprehended how this amphibious ſluggard could make ſuch voyages to places he cannot diſcern. We ſhould have ſeen their heavy fleets, during the night, floating without exertion with the general current of the ocean,—coaſting by moonlight under the dark promontaries of iſlands, and in the deſert bays, for ſome ſandy, quiet ſpot, where they might in repoſe depoſit their eggs.—Others, like mackarels, fail not to arrive at the accuſtomed ſeaſons upon other ſhores, and with the ſame currents, for at that time they are blind. "When mackarels appear on the "coaſt of Canada," ſays Denis, formerly Governor of that country, "they are ſtone blind. "They have a coat over their eyes, which they "only ſhed in June, and then they ſee and "travel to the Line."* His evidence is confirmed by others, which is, however, quite unneceſſary.

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* Nat. Hiſt. of North America, ch. 11.

neceſſary. Other fiſh, like herrings, expoſe their ſilvered tribes to the ſun, upon the northern ſhores of Europe and America, ſhaded with pines, and puſh forward to the palm trees of the Line, going in ſhore againſt the ſouthern tide, which conſtantly brings them freſh ſupplies. Others, like the tunny, by the aid of theſe very tides, enter the Mediterranean in the ſpring, making its entire circuit; and though they have no marks in their liquid furrow, they know it again, in the middle of the darkeſt nights, by the light of the phoſphoric fires produced by their motion. It is the ſame light which diſcovers the ſhady coloured turtle on the ſurface of the waters. Theſe animals, ſurrounded by light, appear to have flambeaux attached to their tails and fins. Thus the phoſphoric quality of ſea waters is connected with the nightly travels of fiſh.

The ſun is the firſt cauſe of all theſe harmonies. Arrived at the equinox, he conſigns one pole to winter, and gives the other the ſignal of ſpring, by the rays with which he envelopes it. The pole, as it heats, pours forth on every ſide its torrents of waters and melting ice, and renews the exiſtence of the ocean. Then begin the changes in its courſe. In its general current, it carries away moſt of the fiſh from the north to the ſouth; and by its counter currents thoſe of the ſouth to the north. It conveys others, by inundations, into the midland continent,—ſuch of the ſcaly breed, as ſalmon, which generally endeavour to move againſt the current of a river.

The floating legions are accompanied by innumerable cohorts of ſea birds, which leave their native climate, and hovering round the fiſh, exiſt at their expence. It is at that time we find the ſea bird of the ſouth landing on our northern ſhores, ſuch as the pelican, the flammans, or , the crabier, or crab-eater, the aigrette, or white heron; and, vice verſa, on the ſouthern ſhores, the birds peculiar to the north, as the lombs, or , the burgomaſters, or , and the cormorants. Then alſo the ſands of the moſt barren rocks are inhabited, and nature preſents new harmonies on every ſhore.

If the voyages made by the inhabitants of the ſea had thrown new lights on the currents of the ocean, the currents of the ocean had equally thrown new light on the forms and cuſtoms of fiſh, which now appear ex-

traordinary

traordinary to us. Moſt of theſe fiſh depoſit their ſpawn in ſuch abundance, that the ſea is ſometimes covered with it for many leagues. The currents diſperſe the ſpawn, and while the parents are indulging their affections on the coaſts of Norway, their offspring are coming to life on the ſhores of Africa, or Brazil. We had ſeen their varied claſſes evidently ſhaped to the different parts of the ocean.—Some, like the long blade of a ſabre, ſuch as the African fiſh, which bear that name, and delight in puſhing through the narrows of rocks, and ſwimming againſt the moſt rapid tides.—Others, equally flat, are perfectly round, with two long horns, projecting from their heads, and falling back to ſerve for a rudder, ſuch as the ſilver moons of the Antilles; theſe moons are continually ſporting among the waves which break againſt the rocks, without being thrown on ſhore.—Others, triangular fiſh, and ſhaped like trunks, from whence they take their name, advance to the middle of the breakers and ponds, where there is hardly any water, and on the black rocks diſplay their green, ſpotted with gold.—While ſome, of a reſtleſs nature, ſearch the ſmalleſt corners of the ſhore for food; others of contented diſpoſition, remain motionleſs, waiting the arrival of their nouriſhment.—Some, cruſted with clumſy habitations of ſtone, pave the bottom, ſuch as the caſques, or , the lambis, or , and the thuillees, or . Others, attached by ligaments to ſmall ſtones, like the mole, remain at an anchor in the entrance of the rivers.—Others, again, cement themſelves together like oyſters.—Others, reſembling the head of a nail, fix themſelves by ſuction to the rocks, like the lepas, or . Others hide themſelves in ſand, like the harpe, or , the vis, or , and the manche de couteau, or , and like the greateſt part of ſhell-fiſh, whoſe exterior coats are clear and brilliant.—Others, like the homars, or lobſters, and the crabs, protected by buckler and corſlet, are in ambuſcade among the ſtones, and only ſhew the end of their horns, and their great claws. Had it been in my power, I had ſtudied the contraſts which theſe innumerable families form on the bottom and on the rocks, where their ſhells are ſeen bright as the morning red, and ſhine like purple and lapis. I had deſcribed thoſe watry fields, covered with plants of infinite variety in ſhape, which only receive the rays of the ſun through the fluid.—Their valleys, through which currents run with the ſwiftneſs of a ſluice, producing elaſtic plants, full of holes, ſuch as the leaves of the panache marin, or , through which the water runs like a ſieve.—I had ſhewn their rocks, which riſe from the bottom like immoveable moles, with hollow flanks, beſet with madrepores, or , and hung with garlands of fucus, or , of algues, or , and of varechs, or , of every colour, ſerving as retreats and reſting places to the phogues, or , and to ſea-horſes.—In tempeſts, the ſhaded beds of the ocean are darkened with clouds, and produce phoſphoric light, and uncommon noiſes, proceeding from their cavities, and calling the ſilent inhabitants of the ſea to their food.—I had endeavoured to have penetrated further, and to have developed myſteries as yet unknown to man, and had noticed the ways of Infinite Wiſdom, moving beneath the waters. But theſe laborious and pleaſing reſearches, ſo advantageous to our fiſheries, and to natural hiſtory, are at preſent beyond my means and my labour.

I dare, however, hope that the new theory I have preſented, on the cauſe of the general currents of the ſea, may be uſeful to navigation. I ſhould ſuppoſe a ſhip ſailing in all March, with the ſet of our polar fuſion, and keeping the middle of the Atlantic canal, may go during the ſummer to the Eaſt Indies, at all times aided by the current. This I could alſo prove by the practice of many ſhips. It is true, during that ſeaſon, which is the winter of the ſouthern hemiſphere, it is dangerous to make the Cape; becauſe the weſtern monſoon, which then prevails, cauſes heavy gales there; and on the coaſts of India, lying oppoſite to the Cape. But I fancy theſe difficulties might be obviated, by increaſing the latitude. The ſame ſhip may return from the Eaſt Indies ſix months after, during our winter, with the fuſion of the ſouth pole. It would, on the contrary, employ the counter currents of the general current, or their lateral tides, to navigate at different ſeaſons along the continents. It is eaſy from this theory to deduce other reſources for the navigation of other ſeas; theſe currents may be employed for the diſcovery of new iſlands, all iſlands being found at the extremity or union of one or more currents, as all volcanos are placed in their remoux, or reaction.

THEORY OF TIDES.

PART III.

ETUDES DE LA NATURE,

PREFACE TO THIRD EDITION.

VOLUME IV. PAGE 10.

I DO not recollect to have added any thing to the ſecond edition, one obſervation excepted, on the counter currents of the Ohio,* which I have alſo introduced in the preſent. But the obſervation is of conſequence, being an additional proof in favour of my hypotheſis on the theory of tides.

The reader will recollect that I refer the northern direction of our ſummer tides to the counter currents of the general current of the

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* A great river in North America, running many hundred miles from Pittſburgh, in the State of Penſylvania, to its junction with the Miſſiſippi.—See Morſe's American Geography.

TRANSLATOR'S NOTE.

Atlantic ocean, which in that ſeaſon proceeds from our pole, whoſe ice is partly melted by the action of the ſun heating it for ſix months. I conjectured that this general current, then ſtreaming to the ſouthward, found itſelf ſtraightened between Cape St. Auguſtine in America, and by the entrance of the Gulph of Guinea in Africa, and produced counter currents on each ſide, giving us our tides, which come to the northward upon our ſhores. Theſe counter currents actually exiſt in theſe places, and are at all times produced on each ſide of a ſtraight, diſcharging a body of water. But I was under no neceſſity of ſuppoſing the reaction of Cape St. Auguſtine, and the entrance of the Gulph of Guinea, to account for our tides flowing far to the northward. The mere action of the general current of the Atlantic, which ſtreams from the north pole, and runs to the ſouthward, impelling a great body of water, which it throws off to the right and left, is enough to produce, on each ſide, thoſe lateral reactions, from whence ariſe our tides which flow to the northward.

I quoted two obſervations on this ſubject, the firſt of which is open to immediate deciſion.—That of a ſtream, which running into a baſon, a baſon, creates on its ſides an eddy or counter current, bringing back the ſtraw, and other floating bodies, to its very ſource.

The ſecond obſervation is taken from Father Charlevoix in his Hiſtory of New France. He relates, that though he had contrary winds, he made eight leagues in the day on lake Michigan,* againſt the general current, by means of the lateral counter currents.

But Mr. Crevecœur, author of the Letters of an American Cultivator,† goes ſtill further, for he aſſerts, that in aſcending the Ohio, along its banks he made 422 miles in fourteen days, which is more than ten leagues per day, "by the aſſiſtance of the eddy, which has "always a velocity equal to the general "ſtream."

Thus the general effect of tides is placed in its ſtrongeſt light, by the example of the lateral counter currents of our baſons, into which ſtreams are diſcharged; by lakes receiving rivers; and by thoſe of rivers themſelves, even in oppoſition to their conſiderable

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* In North America.

† Vol. III. p. 433.

declivity, without any want of ſtraights to produce theſe reactions in the whole extent of their ſhores, though ſtraights will conſiderably augment the counter currents or eddies.*

It is true, the ſet of our tides to the northward, in winter, cannot be explained, as the effect of the lateral counter current of the Atlantic ocean, which comes from the north, ſince its general current ſtreams from the ſouth pole, whoſe ice is melted by the ſun. But the ſet of theſe tides towards the north is ſtill more eaſily conceived as the direct effect of the general current of the ſouth pole, which goes immediately to the north. In this direction, this ſouthern current is almoſt always paſſing from a wider to a narrower place,—firſt confining itſelf between Cape Horn and the Cape of Good Hope, and running into the very bays and inland ſeas of the north, it drives in one maſs the whole volume of the Atlantic

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* The Ohio is, in fact, a long lake, for the current of the Miſſiſippi is ſo much the ſtronger that it ſtops the current of the Ohio, and drives it back in a ſtrong eddy, which is communicated to its very ſource. The ſame may be obſerved of the Miſſiſippi itſelf, and of all rivers, lakes, and ſeas.

Translator's Note.

ocean, without allowing part to eſcape to the right or left.—Yet, if it met in its way any cape or ſtraight, which oppoſed its courſe, it would there certainly form a lateral counter current or tide, ſetting in contrary directions; and this is the effect produced at Cape St. Auguſtine in America, and in Africa, within the Gulph of Guinea, towards the 10th deg. of north latitude, that is, at the two places where theſe two parts of the world are neareſt each other; for in the ſummer of the ſouth pole, the currents and tides, far from going north within theſe capes, return to the ſouthward on the coaſt of America; and to the eaſtward on the coaſt of Africa, along the Gulph of Guinea, againſt all laws of the lunar ſyſtem.

I could produce a volume of new proofs in ſupport of the alternate fuſion of the polar ice, and of the lengthening of the earth at the poles, which are the conſequences of each other. But I have quoted in my former volumes more than are neceſſary to eſtabliſh theſe facts. The ſilence even of the academies on ſuch important ſubjects, is proof that they have nothing to produce againſt me. Had I been wrong in ſtating the ſtrange geometrical error, by which it is concluded that the poles of the earth are flattened, and which clearly demonſtrates their being lengthened, journals had not been wanting to ſilence the opinions of a hermit. I have only met with one which has avowed its ſentiments; amid ſo many literary powers, which are diſputing the empire of opinion, one journal has in my favour ſhewn the flag of truce. It is that of Deux Ponts, to which, in my uſual cuſtom, I publickly make my acknowledgement, though, in the preſent inſtance, it is more a ſervice rendered to truth, than to me, who am perſonally unknown to a writer ſo eſtimable in his impartiality.

On the other hand, if the academies have not explained themſelves, we muſt admit of their diſtreſs, in publickly recanting a geometrical error of ſuch general and eſtabliſhed belief. They cannot ſanction my deductions without condemning their own; and mine they cannot condemn, becauſe eſtabliſhed by their own labours. I have been led only by my attachment to truth, which ought ever to ſupercede individual intereſt. A feeling for my reputation, I muſt confeſs, had alſo its ſhare, though infinitely in the leſſer degree. My chief motive was public utility. I have neither made uſe of ridicule nor enthuſiaſm, againſt men of eminence, convicted of error. I am not intoxicated with my individual reaſon. I have not attributed their error to any want of information, but to the brilliancy of ſyſtems, and eſpecially to the influence of education and moral habits, which veil our judgment with ſuch extraordinary prejudices.

To be convinced that the poles of the world are lengthened, it is not neceſſary to ſolve any highly difficult geometrical problem. The moſt general acquaintance with the laws of geometry and phyſics is amply ſufficient.

Before I collect the proofs which I have already given, and adduce further demonſtration, I ſhall mention the means of aſcertaining the truth, as much with a view to my own conviction as to that of my readers.

We are wandering in utter darkneſs,

"And ſtill quite out at ſea, nor ſee the ſhore."

Here and there we diſcover ſome unconnected facts, as we do an iſland in the middle of the ocean. To attain that iſland, it is not merely enough to know its diſtance to the north or to the weſt. The latitude preſents us with an entire circle; the longitude with another: but the point of interſection determines the exact poſition of the iſland. Thus truth is only to be obtained by conſidering it under various aſpects. Hence an object which we can bring under the inſpection of all our ſenſes, is much better known to us, than another which can only be referred to one of them. A tree is better known to us than a ſtar, becauſe the tree is within our ſight and touch. The bloſſom is better known than the ſtem, becauſe we are able to add the ſenſe of ſmelling to our inquiry; and our obſervations are ſtill more extenſive on the fruit, becauſe we taſte it, and review it with four of the ſenſes at once.—With reſpect to objects to which we can only apply a ſingle organ, ſuch as that of ſight, we ſhall only become acquainted with its merits, by conſidering it in different points of view. A tower on the horizon appears blue, ſmall, and round.—On approach it is white, large, and angular;— it is then concluded to be ſquare.—Go round it, and it is a pentagon.—It is ſo lofty, that it appears impoſſible to aſcertain its height without a quadrant. Take an object of acceſſible height, as that of the obſerver's ſhadow, compared to that of his height, and by a common rule of three, the altitude of the inacceſſible tower is procured.*

Thus it appears, that truth is only to be obtained by conſidering it under various relations. And, therefore, God only is poſſeſſed of knowledge, becauſe only acquainted with the "nice "dependencies," which exiſt throughout nature ; and becauſe he only is univerſally known to all the inhabitants of the earth, having eſtabliſhed an unlimited relation with the ſeveral parts of his univerſe.

Truths are connected with each other, and to poſſeſs, we muſt compare them. Had the academicians made uſe of this principle, they had perceived that the poles being flattened was an error. It was only neceſſary to apply the reſult of ſuch hypotheſis to the partition of waters. If the poles are flattened, their radii being the ſhorteſt on the earth, the waters would have accumulated there, as the loweſt part of the globe. On the other hand, if the equator were ſwelled, the waters would have forſaken it, and the torrid zone would exhibit, in its whole circumference, a belt of dry land, ſix leagues and a half high in the center, ſince the academicians aſſert that the radii of the earth, at the equator, exceed thoſe of the poles by that much.

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* As my ſhadow ; my height : : the ſhadow of the tower : its height.

TRANSLATOR'S NOTE.

But the figure of the earth furniſhes us with appearances exactly the reverſe. The wideſt and deepeſt ſeas are near the equator; and about the north pole the earth extends very far to the northward, and the ſeas which it contains are only mediterraneans, full of banks.

The ſouth pole, indeed, is encompaſſed by an immenſe ocean; but as Captain Cook could not approach it nearer than 475 leagues, we know not whether there is any land about it. It is alſo probable, that nature, which balances and compares all things, has made up the territorial elevation of the north pole, by an equivalent altitude of ice at the ſouth pole; and Capt. Cook found the ſouthern cupola much more lofty and extenſive than the northern,—nor does he admit of any compariſon between them. Speaking of theſe ſolid extremities of ice, which prevented his penetrating further ſouth than the 71 degree of latitude, and which reſembled a chain of mountains, riſing one above the other, and loſing their ſummits in the clouds, he ſays, in January 1774, "I "fancy ſuch mountains of ice were never ſeen "in the Greenland ſeas—at leaſt I never heard "or read of ſuch; nor is any compariſon to "be drawn between the ice of the north pole "and that of the ſouth."

This wonderful altitude of ice, of which Cook only ſaw one extremity, may then be equivalent to the territorial elevation of the northern pole, which has been aſcertained by the diſcoveries of the academicians; but, although the frozen ſeas of the ſouthern pole refuſe all acceſs to geometricians, we ſhall yet trace, by two authentic obſervations, that its unfrozen ſeas are more elevated than thoſe of the equator, and of the ſame height with thoſe of the northern pole:—And we ſhall at the ſame time prove the prolongation of the poles, by uſing the method adopted to prove their being flattened. This hypotheſis has produced further proof of its falſity, by being applied to the diſtribution of the land and waters of the globe; that of the lengthening of the poles will acquire further credit, by applying it to the various harmonies of nature. Among the proofs which I have before adduced, will be found ſome geometrical, ſome geographical, ſome atmoſpheric, ſome nautical, and ſome aſtronomical.

1ſt. The firſt proof of the lengthening of the poles is geometrical, and is enough to throw on that truth, the laſt degree of evidence. It is eaſily ſuppoſed, that if in a circle the degrees or portion of that circle become longer, the whole portion of that circle muſt become longer alſo; but the degrees of a meridian become longer under the polar circle, becauſe they are greater than thoſe at the equator, according to the academicians. The polar arc, then, muſt alſo become longer. I have already brought forward this argument to prove the polar circle is not flattened; I may alſo uſe it to prove it lengthened.

2dly. The ſecond proof of the poles being lengthened, is atmoſpheric; for the altitude of the atmoſphere decreaſes, as we aſcend a mountain; and this altitude alſo decreaſes as we approach the pole. I have on this ſubject two experiments of the barometer; the firſt for the northern, and the ſecond for the ſouthern hemiſphere. The barometer at Paris falls one line, at eleven toiſes, or fathoms, of elevation. It falls alſo one line in Sweden, if only raiſed ten toiſes, or fathoms, one foot, ſix inches, and four lines. The atmoſphere, then, in Sweden, is ſo much lower, or, which is the ſame thing, its continent is higher than at Paris, and, therefore, the earth lengthens to the northward. This experiment and deduction cannot be rejected by academicians, for they are taken from the Annals of the Academy of Sciences.*

3dly. The third obſervation, on the depreſſion of the atmoſphere at the poles, was made at the ſouth pole. It is a ſucceſſion of daily barometric obſervations, in the ſouthern hemiſphere, by Capt. Cook, in the years 1773, 1774, and 1775. In them we ſee the mercury ſcarcely riſe above 29 inches, ſouth of the ſixth degree of latitude; and almoſt always to 30 inches and beyond it, when nearing the torrid zone,—which proves that the barometer fell when approaching the ſouth pole, as it did when approaching the north, and that conſequently they each of them are lengthened. The table of theſe obſervations may be ſeen

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* Of the year 1712, p. 4.

at the end of Capt. Cook's ſecond voyage. Thoſe of the ſame nature, which were made in the next voyage, give us no regular difference, whatever be the latitude of the ſhip, which proves their inaccuracy; probably occaſioned by the ſucceſſive deaths of the obſervers, ſuch as the learned Anderſon, ſurgeon of the ſhip; that of Capt. Cook, and of his ſucceſſor, Capt. Clarke.

4thly. The fourth proof of the lengthening of the poles is nautic, and founded on ſix experiments, of three different kinds. The two firſt are taken from the annual deſcent of the polar ice towards the Line;—the two next, from the currents proceeding from their reſpective poles during the ſummer;—and the two laſt, from the rapidity and extent of theſe very currents, which, in alternate ſucceſſion, perform the circuit of the world, each in ſix months. Of theſe experiments, three appertain to the north, and three to the ſouth pole.

The firſt experiment, taken from the deſcent of the ice from the north pole, is ſupported by the teſtimony of the moſt eminent navigators in the northern ſeas. Among others, of Ellis, Linſchoten, Barents, Martens, and Denis, Governor of Canada, who atteſt that the ice is of prodigious elevation, and often met in the ſpring, in moderate latitudes.* Denis ſays they are loftier than the towers of Notre Dame,† that they ſometimes form a chain of more than one day's ſail, and that they ground on the banks of Newfoundland. The northern parts of the bank are not higher than the 50th degree of latitude, and the whalers only meet the ſolid maſs of ice towards the 75th degree of latitude; but ſuppoſing the ice, in winter, to extend from the pole to the 65th degree of latitude, the floating ice, which leaves it, muſt traverſe 375 leagues in the two firſt months of the ſpring. It is not the wind which impels it to the ſouthward, ſince the fiſhermen generally have fair winds. Variable winds would carry them indifferently to the northward, eaſtward, or weſtward; but they are conveyed every year by the northern current towards the Line, becauſe the pole, from whence it flows, is more elevated.

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* By his Majeſty's ſhip Formidable, between lat. 40 and 41 N. in July 1783.—A ſmall iſland was ſome years ago towed into Carliſle Bay, Barbadoes.

† At Paris.

TRANSLATOR'S NOTE.

5thly. The ſecond experiment of the ſame nature is for the ſouth pole, and is taken from Capt. Cook's Voyage in 1774.—" On the " 10th of December, at eight in the morning, " we diſcovered ice to the weſtward ;" and Mr. Foſter adds, " about two leagues to wind- " ward, another maſs, which looked like a white " point of land.—In the afternoon we paſſed " near a third, which was cubical, and two " thouſand feet in length, four hundred in " breadth, and at leaſt two hundred in height." Cook was then in 51° ſouth and two degrees weſt of the Cape of Good Hope. He ſaw many more, till the 17th of January 1773 ; but at that time, being in 65° 15′ of ſouth latitude, he was ſtopped by an irregular body of ice, which prevented his going farther ſouth ; ſuppoſing, then, the firſt ice he met with, on the 10th of December, to have left this body the 10th of October, which is the time the power of the ſun begins to diſſolve the ſouthern ice, it muſt have travelled fourteen degrees towards the Line, or, 350 leagues in two months,—that is, nearly the ſame diſtance, and in much the ſame time, with that which proceeds from the north pole. Therefore, the ſouth pole, like the north pole, is more elevated than the equator, ſince its ice ſtreams to the torrid zone.

6thly. The third nautic experiment, to prove the north pole is lengthened, is taken from the currents which immediately ſtream from the bays and ſtraights in the north, with the rapidity of a ſluice. I have, on this ſubject, cited the ſame northern navigators, Linſchoten; Barents, ſent by the Dutch to diſcover a N. E. paſſage to China; and Ellis, by the Engliſh, to the bottom of Hudſon's Bay, to diſcover a N. W. paſſage to the South ſea.—They found in theſe northern ſeas, currents, proceeding from their reſpective bays and ſtraights, running at the rate of eight or ten leagues an hour, and carrying with them an incalculable quantity of floating ice, and tides the moſt rapid, which, like the currents, iſſued immediately from the N. E. and N. W. according to the poſition of the land. It is from theſe regular and various facts, that I am convinced the fuſion of the polar ice is the ſecondary cauſe of the movement of the ocean, the ſun being the primary cauſe.

7thly. The currents of the South ſea alſo take their origin at the ſouth pole. Cook ſays of them, in January 1774, "My opinion, and that of "moſt of the officers, was this; that the ice "extended to the poles, or that, perhaps, it "ſurrounded ſome land, to which it had been "attached from the moſt remote antiquity.— "That to the ſouthward of this parallel was "formed all the ice we met with to the northward; and that afterwards, detached from "it by gales of wind, or other cauſes, it is "thrown to the northward by the currents, "which in the high latitudes we invariably "found to ſet in that direction."

Thus a fourth nautic proof aſcertains the ſouth pole to be lengthened, as the north pole is; for, if they both were flattened, the currents would ſet to them, inſtead of running to the Line.

The ſouthern currents are not ſo ſtrong at their ſource as the northern, becauſe they are not like the laſt, collected in bays, and there iſſued through ſtraights; but we ſhall find they extend equally far.

8thly. The fifth nautic proof, of the elevation of the poles above the horizon of every ſea, is taken from the rapidity and extent of their currents, which run the circuit of the world. I have before cited, that of the Indian ocean, which ſets ſix months to the eaſt, and ſix months to the weſt, according to the aſſertion of all eaſtern navigators. I ſhowed that this alternate and ſemi-annual current could not be deduced from the ſun's or moon's orbit, which always go from eaſt to weſt; but to the united heat of theſe planets, which alternately, during ſix months, melt the ice of each pole.

I have alſo adduced two very curious facts, to prove that a ſimilar alternate and ſemi-annual current prevails in the Atlantic ocean, where it, even now, is not admitted to exiſt. The firſt is that of Rennefort, who, in the month of July 1666, ſailing from the Azores, obſerved the ſeas covered with the wreck of a naval fight, which nine days before had taken place between the Engliſh and Dutch, off Oſtend. This wreck, in nine days, travelled more than 275 leagues to the ſouthward, which gives it thirty-four leagues per day; and is a fifth nautic proof, from the rapidity of the northern currents, that the pole is conſiderably more elevated than the horizon of other ſeas.

9thly. The ſixth nautic experiment, particularly eſtabliſhes the elevation of the ſouth pole, by the extent of its currents, which in winter are impelled to the extremity of the Atlantic ocean, and is the obſervation of Mr. Pennant, a celebrated Engliſh naturaliſt, who reports, that the maſts of the Tilbury* ſhip of war, burnt at Jamaica, was thrown by the ſea upon the coaſt of the Hebrides; and that annually, on the ſhores of theſe iſlands, are taken up the ſeeds of plants, which only grow in and about Jamaica. Cook alſo aſſures us, in his Voyages, as an authentic fact, that every year, on the coaſts of Ireland, are found great quantity of flat and round ſeed, called bulls eyes, which only grow in America.

10thly and 11thly. The aſtronomical proofs of the poles being lengthened, are three in number. The two firſt are lunar; and the double obſervation of Tycho Brahé, and Kepler, who, in central eclipſes of the moon, perceived the ſhade of the earth lengthened at the poles. Nothing can be objected to the ſights of two ſuch celebrated aſtronomers, whoſe calculations, far from being aſſiſted, were deranged by their obſervation.

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* Vide note, p. 61.

12thly. The third aſtronomical proof, of the poles being lengthened, is ſolar, and has reference to the north pole. It is the obſervation of Barents, who, from Nova Zembla, in latitude 76 N. ſaw the ſun on the horizon fifteen days ſooner than he expected ; the ſun, in this caſe, was 2½ degrees higher than it ought to have appeared ; and, in that latitude, allowing 1 deg. and even 1′ 30″, for the refraction of the atmoſphere in winter, which is very conſiderable, there remains, at leaſt, one degree, for the elevation of the obſerver, on the horizon of Nova Zembla. I have noticed, on this ſubject, another error of the academician Bouguer, who only gives 34′ for the greateſt refraction of the ſun in all climates.

Theſe twelve proofs, taken from various harmonies of nature, mutually agree in eſtabliſhing that the poles are lengthened. They are ſupported by a multitude of facts, to which I could add others ; while the academicians cannot refer their hypotheſis, of the poles being flattened, to any phænomenon of the earth, ſea, or atmoſphere, without immediately perceiving its fallacy ; but geometry alone is enough to confute them.

Indeed, the vibrations of the pendulum are brought to agree with their theory; but this experiment is liable to numberleſs errors,—and is at leaſt as ſuſpicious as that of the burning glaſs, which induced them to believe that the rays of the moon were void of heat, though the contrary has been proved at Rome and Paris, by Profeſſors of Phyſic. The pendulum lengthens by heat, and contracts by cold; and it is very difficult to balance theſe variations by an aſſemblage compoſed of rods, of different metals.

It being proved, then, that the poles are lengthened, the currents of the ſea, and its tides, are naturally deduced.

Many perſons obſerving that a ſimilar increaſe and decreaſe take place between the tides of the ſea and the phaſes of the moon, are perſuaded that this planet, by its attraction, is their primary cauſe; but theſe agreements only exiſt in certain parts of the Atlantic ocean;—they proceed, not from the attraction of the moon upon the waters, but from the reflected heat of the ſun on the polar ice, whoſe fuſions it increaſes, according to the particular laws of our continents. In all other places, the number, change, duration, irregularity, and regularity of the tides, have no relation with the phaſes of the moon; but, on the contrary, proceed from the effects of the ſun on the polar ice, and from the formation of the poles. This I ſhall endeavour to prove.

If the moon acted by attraction, upon the tides of the ocean, ſhe would equally exert that power on inland ſeas and on lakes. But that is not the caſe; ſince inland ſeas and lakes have not any tides, at leaſt lunar tides. We have noticed that lakes, ſituated at the foot of mountains of ice, are ſubject in ſummer to ſolar tides, that is, have a flood like the ocean. Such as the lake of Geneva, which has a regular flood every afternoon. This agreement between the flood of lakes, ſituated near mountains of ice, and the heat of the ſun, gives the higheſt probability to my theory of tides; and, on the contrary, the diſagreement between theſe floods and the phaſes of the moon, and the quiet of inland ſeas, when this planet paſſes their meridian, muſt weaken our belief in its power of attraction. But we are about to obſerve, that in the ocean itſelf the greateſt number of the tides have no relation with the moon's attraction or orbit. I have already quoted the navigator Dampier, who relates that the higheſt tide which he experienced on the coaſt of New Holland, was not felt till three days after the full. He, among other navigators to the ſouthward, aſſures us that the tides riſe very little between the tropics, and that they are at moſt of four or five feet in the Eaſt Indies, and of one foot and a half only on the coaſts of the South ſea.

I cannot but aſk, why the tides between the tropics, under the immediate action of the moon, are ſo weak and retarded? Why the moon, by its attraction, gives us two tides a day in the Atlantic ocean, and only one, in many parts of the ſouthern ocean, which is ſo infinitely larger? Why, in the South ſea, are there diurnal and ſemi-diurnal tides, that is, of twelve and of ſix hours? Why does the flood generally return there at the ſame hour, and to nearly the ſame height, the whole year round, whatever be the changes in the phaſes of the moon? Why do ſome increaſe in the quarters of the moon, as they do at the new and at the full? Why are they always ſtronger as they near the poles, and often ſtream toward the Line, againſt the pretended principle of their motion? Theſe problems, ſo irreſolvable by the power of attraction at the equator, ceaſe to be ſo, as the effect of the alternate fuſion of the poles.

I ſhall endeavour to prove this diverſity of tides, by the evidence of perſons who were zealous partizans of Newton's ſyſtem. My witneſſes are not obſcure, but ſcientific men, officers in the King's navy, ſucceſſively charged by their country to make the round of the world, and collect uſeful information towards the ſtudy of nature.—Such as Captains Byron, Carteret, Cook, Clarke, and the aſtronomer, Mr. Wales; I ſhall adduce the teſtimony of Newton himſelf. Let us firſt notice what the circumnavigators remark on the nature of the tides in the ſouthern parts of the South ſea.

In the roadſted of the iſland of Maſſafuero, in latitude 33° 46′ S. and longitude 80° 22′ W. from London, Capt. Byron, in April 1765, ſays, "The ſea runs twelve hours to the north, and "returns for twelve hours to the ſouth."

It appears, then, that the tides in the iſland of Maſſafuero, ſituated in the ſouth part of the ſouthern ocean, in April run to the northward, and go towards the Line, againſt the lunar ſyſtem; and its tides are of twelve hours, which is an additional difficulty.

In Engliſh Harbour, on the coaſt of New Britain, in lat. 5° S. long. 152 W. Capt. Carteret, in Auguſt 1767, ſays, "The tide "has its flood and ebb, once in twenty hours."

In the Bay of Iſlands, in New Zealand, in lat. 54° 59′ S. and long. 185° 36′ W. Capt. Cook, in December 1769, ſays, "From the "obſervations I have been able to make, on "the ſubject of tides, it ſeems that the flood "comes from the ſouth."

All theſe are tides in the open ſea, ſetting towards the Line, againſt the impulſe of the moon. At that ſeaſon they reach New Zealand, from the ſouth pole, whoſe currents were then in activity, for December is the ſummer of that pole. That of Maſſafuero, though obſerved in April by Capt. Byron, had the ſame ſource, becauſe the currents of the north pole, which only began in the end of March, the time of our vernal equinox, had not yet checked the powers of the ſouth pole in the ſouthern hemiſphere.

At the mouth of Endeavour River, in New Holland, in lat. 15° 26′ S. and long. 214° 42′ W. where Capt. Cook refitted after ſtriking the ground, he ſays, in June 1770, " the flood " and the ebb were only felt once in the " twenty-four hours, which we perceived while " the ſhip was on the rocks."

At the entrance of Chriſtmas Harbour, in Kerguelen Land, lat. 48° 29′ S. long. 68° 42′ E. Capt. Cook ſays, in December 1776, " while " we were at an anchor, we obſerved the flood " came from the S. E. at the rate of at leaſt two " miles an hour."

Here then, is another tide which ſets directly from the ſouth pole. It ſeems this tide was regular, and daily,—that is, of twelve hours; for Cook adds, ſome pages after, " It " is high water about ten o'clock, at full and " change, and the flood riſes and falls about " four feet."

At Otaheite, in lat. 17° 29′ S. long. 149° 35′ W. Capt. Cook ſays, in December 1777, we " alſo made ſome obſervations on the tides, and " wiſhed to aſcertain their greateſt riſe. During

my

“ my ſecond voyage, Mr. Wales thought the flood “ roſe higher than I imagined it did in 1769. “ We now proved that this difference was not “ real; that is, that the tide only roſe twelve “ or fourteen inches at moſt. We obſerved it “ to be high water at noon in the quarters, as “ well as at the full and change.” Capt. Cook gives a table of tides for theſe iſlands, from the 1ſt to the 26th November,—whence it is clear that there is only one tide each day, which, throughout the whole of the month, was at its mean height, between the hours of eleven and one. It is then plain that tides ſo regular, at ſuch different ages of the moon, have not any relation with the phaſes of that planet.

Capt. Cook was at Otaheite, in July 1769, that is, in the winter of the ſouth pole. He was there again in December, 1777, which is its ſummer; the fuſions of that pole, being at that time of the year more ample, and contiguous to Otaheite, than thoſe of the north pole, it is probable the tides would be ſtronger in December than in July; and that Mr. Wales was right.

Let us now follow the tides in the northern part of the South ſea.

At the entrance of Nootka, in America, lat. 49° 36′ N. long. 233° 17′ E. Capt. Cook ſays, in April 1778, "It is high water at 12 h. 28′, "at full change. The tide riſes eight feet nine "inches. I ſpeak of the morning tides, and "of thoſe which happen two or three days "after the full and change. The night tides are "then two feet higher. This very conſiderable "elevation was very viſible at high water of "the full moon, which took place ſhortly after "our arrival. It ſeemed evident the ſame "would take place upon the flood of the new "moon. We did not however continue there "ſufficiently long to decide with certainty."

We find then, on the oppoſite ſide of our hemiſphere, ſemi-diurnal, or two tides in the day ſimilar to our own; while there only appears to be one in the ſouthern hemiſphere, that is, in the South ſea only. But theſe ſemi-diurnal tides differ from ours, in their return at the ſame hour, and in their greateſt height being only two or three days after the full. We ſhall ſhortly give the reaſons of theſe phænomena, inexplicable by the lunar ſyſtem.

In the two following obſervations we ſhall trace theſe northern tides of the ſouthern ocean, obſerved in the month of April, and find them become ſtronger in the month of May, in higher latitudes, and on the ſame coaſt; and ſtill ſtronger in June, which cannot in any meaſure be aſcribed to the courſe of the moon, which is then paſſing in the ſouthern hemiſphere; but to the effect of the ſun, which at that time is in its northern tract, and every day gives additional heat to the north pole, whoſe fuſion increaſes with the increaſing power of that planet. Beſides, the direction of theſe tides from the north towards the line, added to other circumſtances, will plainly prove their ſource to be at the pole.

At the mouth of Cook's River, in America, in lat. 57° 51′ N. Capt. Cook ſays, in May 1778, "we here obſerved a very ſtrong tide, "which, without the harbour, ſet to the ſouthward. It was the making of the ebb, which "ran from three to four miles an hour, and it "was low water at ten o'clock. The tide "carried with it, out of the river's mouth, a "great number of dalgues marines, or   , "and of floating wood. The water was thick, "like that of rivers; but we were principally "induced to purſue our route, from finding the

" river, at low water, as ſalt as the ſea. The " flood ran three miles per hour, and till four in " the afternoon." Having gone up this opening to a place where it was only four leagues over, Capt. Cook ſays, on the 30th of May, 1778, " the " tide had wonderful force and ſwiftneſs, and " was alarming to us, who did not know whether " the agitation of the " waters was owing to " the ſtrength of the tide only, or to the " ſea running againſt rocks and ſand banks. " We remained at an anchor during the ebb, " which ran nearly five miles an hour; as yet " we found the ſtream, at high and at low " water, equally ſalt, and at both times as " much ſo, as that of the ocean. We ſoon " had ſymptoms which aſſured us we were " puſhing up a river. The water towards " the laſt of the ebb, was much freſher than " that taſted before. I am convinced we were " in a great river, and not in a ſtraight, communicating with the ſeas of the north."

That which Capt. Cook calls the entrance, and which ſince has received the name of Cook's River, is, by its courſe, and by its brackiſh waters, neither a ſtraight nor a river, but a real northern ſluice, by which the fuſions of the polar ice are vented into the ocean. Similar outlets are found in the bottom of Hudſon's Bay. Ellis was deceived by them, and took them for ſtraights, communicating from the North to the South ſea. To raiſe the doubts exiſting on this ſubject, Capt. Cook made ſimilar experiments to the northward of the coaſt of California; and adds, in June 1778, " when we had reached the Bay, the flood " ſet with ſtrength into Turnagain River, and " the ebb had ſtill ſtronger force. The ſea fell " twenty feet while we were at an anchor."

That which Capt. Cook calls the ebb, ſeems to me the flood, for it was more violent and rapid than what he ſtiles the flood; the laſt generally produces a bar, which the firſt does not.

Capt. Cook, truſting to the received opinion, that the cauſe of the tides lay between the tropics, could not accuſtom himſelf to conſider this flood, which proceeded interiorly from the land, as an abſolute tide; yet, on the oppoſite ſide of this very continent, I mean in the bottom of Hudſon's Bay, the flood comes from the weſt, that is, from the interior land.

The following paſſage is taken from the introduction to the third of Captain Cook's voyages.

" Capt. Middleton, in a voyage to Hudſon's
" Bay, in 1741 and 1742, found, between the
" 65th and 66th degree of latitude, a very
" large opening to the weſtward, into which
" he puſhed with his ſhips. Having often
" examined the tides, and endeavoured for
" three weeks to diſcover the nature and
" interior direction of the opening, he found
" that the flood always came from the weſt,
" and that he was in a great river, which he
" named Wager."

" Mr. Dobbs refuſed to admit the accuracy, or
" rather the fidelity of theſe details. He affirmed,
" that Middleton's River is a ſtraight, and not
" a river of freſh water; and that if Middleton
" had carefully examined it, he had found a
" a paſſage to the weſtern American ocean.
" The little ſucceſs, then, of the expedition did
" but furniſh Mr. Dobbs with further argu-
" ments for once more attempting that paſſage;
" and having by act of Parliament procured
" a recompence of 20,000l. for this diſcovery,
" he prevailed on a company of merchants to

" fit out the Dobbs and California. It was ex-
" pected theſe ſhips would effect a paſſage to
" the Pacific ocean, by the opening diſcovered
" in Middleton's voyage, and on which it was
" ſuppoſed that navigator, in his report, had
" deceived the public."

" This expedition was not more ſucceſsful
" than the former. It is known that the voyage
" of the Dobbs and California, tended to eſta-
" bliſh, and not to invalidate, Middleton's aſſer-
" tions. It was found that the opening was
" but a river of freſh water, and aſcertained to
" what extent it was navigable to the weſt-
" ward."*

Thus, then, Wager's River produces a real tide from the weſt, becauſe it is one of the ſluices which leads from the north into the Atlantic ocean. It is then evident, that the Great, or Cook's River, produces a real tide from the eaſt, becauſe it is alſo one of the northern ſluices into the ſouthern ſea.

Beſides the rapidity and the riſe of the tides in Cook's River, ſimilar to thoſe in the bottom of Hudſon's Bay, and in the ſtraights of Waigats, &c ; the diminution of their ſaltneſs, and their general direction towards the Line, prove that in ſummer they are equally formed in the north of the Pacific ocean, and in the north of the Atlantic ocean, by the fuſion of ice ſurrounding that pole.

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* Mr. Ellis, whom I have ſo often quoted, went on this diſcovery, and wrote the account of it.

In the proſecution of Capt. Cook's voyages by Capt. Clark, we ſhall find two other obſervations on the tides, which are not reſolvable by the lunar ſyſtem.

At the obſervatory in the Bay of Karacakooa, at the Sandwich Iſlands, in lat. 19° 28′ N. long. 204 E, Capt. Cook, in May 1779, ſays, "the tides are very regular ; the flood and "the ebb are of ſix hours. The flood comes "from the eaſt, and it is high water at full "and change, at 3 hours and 45 minutes of "apparent time."

At the village of St. Peter and St. Paul, in Kamtſchatka, lat. 53° 38′ N. long. 158° 43′ E. Capt. Clarke, in October 1779, ſays, "it was "high water, at full and change, at 4 h. 36 "min ; and its higheſt riſe was of 5 feet 8 "inches ;

" inches; the tides are of 12 hours, and very
" regular."

Capt. Clarke, like Capt. Cook, perſuaded of the moon's attraction in the torrid zone, in vain attempts reconciling the irregular phaſes of that planet, to the regularity of the tides, which take place at fixed hours in the South ſea; and other their phænomena. Mr. Wales, on this ſubject, confeſſes the inefficiency of the Newtonian ſyſtem. He ſays, in the introduction to the laſt of Cook's Voyages, " the
" obſervations, on the riſe and periods of the
" tides, are, in theſe voyages, in great number,
" and produce uſeful and important details.
" Among theſe obſervations, ſome very curi-
" ous and unexpected circumſtances preſented
" themſelves. It will be here ſufficient to
" notice the very little riſe of the tides in the
" middle of the Pacific ocean. We found it
" two-thirds leſs than theory and calculation
" taught us to expect it."

The followers of Newton's ſyſtem would be ſtill more embarraſſed were they called upon clearly to explain, why there are two tides of ſix hours in the Atlantic ocean? Why there is only one of twelve hours in the ſouthern part of the South ſea, as at Otaheite; on the coaſt of New Holland; on that of New Britain; at the iſle of Maſſafuero, &c.? and why, in the northern parts of the South ſea, the two tides of ſix hours daily reappear; of equal duration at the Sandwich Iſlands; of unequal duration at Nootka, on the coaſt of America? and why in the ſame latitude, at Kamſchatka, on the coaſt of Aſia, returned to a ſingle tide of twelve hours?

I could cite others ſtill more extraordinary. Theſe numerous and characteriſtic irregularities between the motion of the tides, and the courſe of the moon, few of which, however, were known to Newton, obliged him to acknowledge, as I have before mentioned, "that there "muſt be, in the periodic return of the tides, "ſome further mixed cauſe, as yet undiſ-"covered."*

This further, mixed, and as yet undiſcovered cauſe, is the fuſion of the ice at the poles, which in winter have from five to ſix thouſand leagues in circumference, and at moſt from two to three thouſand in their ſummer. Theſe

bodies

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[*] Philoſophie de Newton, chap. 18, by Voltaire.

bodies of ice being alternately melted, and ſtreamed into the ocean, produce all the phænomena. If in our ſummer there are, in the Atlantic ocean, two tides in each day, it proceeds from the alternate fuſion of the two continents, the new and the old, which approach each other towards the north. One of theſe during the day, and the other during the night, yields the waters of its ice, melted by the ſun, on the eaſt and weſt ſide of the pole, which it daily ſurrounds, and ſemi-annually heats with its fires. If there is a delay of 22 minutes between one tide and the next, it is becauſe the cupola, of the pole in fuſion diminiſhes every day, and that its melted waters are retarded by the windings of the Atlantic canal. If our coaſts are alſo viſited by two daily tides, during our winter, it is becauſe the fuſions of the ſouth pole, on their entrance into the Atlantic canal, ſuffer two independant changes of direction, one at Cape Horn, and the other at the Cape of Good Hope. I conclude theſe alternate affections of the ſouthern fuſions render theſe two capes, which firſt receive its ſhock, ſo tempeſtuous; and to ſhips paſſing from the Atlantic, ſo difficult to double, during the ſummer of their pole, for they then meet the currents ſtreaming from the ſouth. For this reaſon it is very difficult to double the Cape of Good Hope, in December, January, February, and March, in the paſſage to India; and, on the contrary, it is eaſily paſſed during our ſummer months, becauſe, then, aſſiſted by the currents of the north pole, which ſtream out of the Atlantic. The contrary is experienced in returning from India, during our winter months.

I am induced, from theſe reflections, to believe, that ſhips bound to the South ſea would find leſs difficulty in paſſing Cape Horn, in its winter, than in its ſummer, not being then impeded by the currents of the ſouth pole running into the Atlantic; but, on the contrary, aſſiſted in their paſſage by thoſe from the north pole. I could ſupport this opinion by the practice of many ſhips. That of Lord Anſon may be objected to me; but he only doubled that Cape in March and April, two of the moſt tempeſtuous months of the year, from the general revolution of the atmoſphere, and of the ocean, which takes place at the equinox, when the ſun paſſes from one hemiſphere to the other.

Let us, on the ſame principle, explain why the tides of the South ſea are not ſimilar to thoſe of the Atlantic. The ſouth pole has not, like the north pole, a double continent, which divides its daily fuſions into two ſtreams. It has not any continent; it therefore has not any canal, in which its waters are retarded, and, conſequently, they flow immediately into the vaſt ſouthern ocean, forming, on one half of the pole, a ſucceſſion of diverging fluid rays, which, like thoſe of the ſun, perform the circle of the pole in twenty-four hours. When one of the rays of this fuſion meets with an iſland, it brings with it a tide of twelve hours, that is, of an interval equal to that employed by the ſun, in heating the correſponding moiety of the icy cupola, through which the meridian of ſuch iſland paſſes. Such are the tides of the iſles of Otaheite, Maſſafuero, New Holland, New Britain, &c. Each tide continues as long as the ſun remains on the horizon, and is regular as its courſe. Thus, while the ſun vertically, for twelve hours, heats the iſlands of the South ſea, it refreſhes them by a tide of twelve hours, which by its horizontal fires it draws from the ice of the poles. Contrary effects are often produced by ſimilar cauſes.

This order of the tides is no longer the ſame in the northern parts of the ſouthern ocean. In that oppoſite part of our hemiſphere, the two continents approach to the northward. During the ſummer, they alternately pour into the canal, which ſeparates them, the two ſemi-diurnal fuſions of the north pole, and in winter ſucceſſively receive thoſe of the ſouth pole, each day producing two tides, as in the Atlantic ocean; but, as this canal formed to the northward of the North Pacific ocean, by the two continents, is very wide below the 55th degree of latitude, or rather ceaſes to exiſt, by the ſudden expanſion of America and Aſia, which there ſeparate to the eaſt and weſt, it follows that a double tide is felt only in the projection of the currents iſſuing from the northern ſhores of theſe continents; ſuch as at the Sandwich Iſlands, preciſely ſituated at the confluence of theſe two currents, and at a proportioned diſtance from America and Aſia, in lat. 21°. N. When this place is more open to the current of one continent than to that of the other, theſe ſemi-diurnal tides are unequal, as they are at the entrance of Nootka, on the coaſt of America; but when quite out of the influence of the one, and totally within that of the other, it receives but one tide a day, ſimilar to that at Kamtſchatka on the coaſt of Aſia; and the tide is then of twelve hours, agreeing with the action of the ſun upon one half of the pole, whoſe fuſions are not then ſubject to any diviſion.

Hence it appears that two ports may be ſituated in the ſame ſea, and under the ſame parallel, the firſt having two tides a day, and the other but one; and that the duration of theſe tides, whether diurnal or ſemi-diurnal, equally or unequally divided, regular or retarded, are always of twelve hours in twenty-four hours, that is, of the exact interval the ſun takes to heat the moiety of the cupola from whence they ſtream, which cannot be referred to the unequal courſe of the ſun within the tropics, and ſtill leſs to that of the moon, which is ſometimes but a few hours above the horizon.

I have, then, by plain, clear, and numerous facts, eſtabliſhed the want of uniformity between the tides of ſeveral ſeas, and the ſuppoſed attraction of the moon on the equator; and, on the contrary, their uniformity with the action of the ſun on the ice of the poles.

I ſhall notice, that though the South ſea apparently preſents no canal to the courſe of the polar fuſions, from the great ſpread of America and Aſia, yet a canal is evidently formed by the projection of its archipelagos, which are ſituated relatively to the two continents. It is by means of this canal that the Sandwich Iſles, which are in the north part of the South ſea, in lat. 21. are each day ſubject to two tides, by the fuſions from America and Aſia, though the ſtraights, which ſeparate theſe continents, are in the 65th degree of north latitude. Not that theſe iſlands and this ſtraight to the northward are exactly under the ſame meridian; but the Sandwich Iſlands are placed in a curve, correſponding to the curve of America, whoſe origin would be in the ſtraight to the northward. This curve might be followed to iſlands ſtill more diſtantly ſituated in the South ſea, which receive two tides each day, and, as before noticed, would point out the current produced by the fuſion of America and Aſia. All iſlands are ſituated in the middle of currents. Taking, then, a bird's eye view of the ſouth pole, a number of archipelagos are obſerved, arranged in ſpiral directions, as far as the northern hemiſphere, which point out the current of the South ſea, as the projection

of

of the two continents towards the north pole, exhibits the current of the Atlantic. Thus, then, the progreſs of the ocean, from one pole to the other, is ſpiral round the globe, and ſimilar to the courſe of the ſun within the tropics.

Theſe obſervations furniſh us with additional probabilities on the relative movements of the ſea and the ſun. Not that the chain of iſlands, ſpirally placed in the South ſea, is uninterrupted; but theſe interruptions, in my opinion, ariſe from the imperfect ſtate of our diſcoveries. We might, I fancy, extend them much further, by adapting to the diſcovery of other iſlands, our knowledge of thoſe already known. Voyages ſhould not be made by going ſtraight to the ſouth pole, or by ſailing round the world in the ſame parallel of latitude, which is generally the caſe; but in following the ſpiral ſpoken of, and ſufficiently pointed out by the general current of the ocean. Attention ſhould alſo be had to the nautic fruits, which the alternate currents of the ſea regularly convey from one iſland to another, and frequently to prodigious diſtances.

By theſe plain and natural means, the ancient inhabitants of the ſouth of Aſia, diſcovered ſo many iſlands in the South ſea, where their language and cuſtoms are ſtill to be traced. Thus, by truſting to nature, which often directs us better than our knowledge, they landed, without quadrant or chart, among a number of iſlands, totally unknown to them.

Speaking of the Atlantic hemiſphere, and on the ſubject of Columbus, who was near foundering on his firſt return from America, we find he put the narrative of his diſcoveries into a caſk, and committed it to the ſea. On this ſubject I ſaid, a mere glaſs bottle could preſerve it for centuries on the ſurface of the ocean, and carry it more than once from pole to pole. This experiment has, of late, been partly realized on the coaſts of Europe,* and is thus reported in the French Mercury† of Saturday, Jan. 12, 1788.—" In " the

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* I recommend it to thoſe who intereſt themſelves in the progreſs of natural hiſtory, to repeat this experiment, in itſelf ſo eaſy and ſo cheap. By fitting the bottle with an upright rod, and faſtening to it a piece of linen, or ſome feathers, it would be diſcovered at a conſiderable diſtance. The bottles ſhould be twiſted round with line, to prevent their being broken when thrown upon the ſhore, to which, ſooner or later, the currents would convey them,

† No. 2. page 84, 85. Political part.

“ the month of May of this year, ſome fiſher-
“ men of Arromanches, near Bayeux, found in
“ the open ſea a little bottle, well corked; and
“ impatient

them. Theſe trials, ſo apparently trifling, may become of the greateſt importance to mariners. They may ſerve to diſcover the direction and velocity of currents, in a manner much more extenſive and certain than by the log, * or by boats. The laſt method, though often practiſed by the celebrated Cook, can only give the relative velocity of the ſhip and the boat, and not the intrinſic velocity of the current. In ſhort, theſe trials, however uncertain, may aſſiſt mariners in conveying information to their friends, at great diſtances from the land, or procure them ſupplies, if wrecked upon ſome deſart iſland.

We do not ſufficiently confide in nature; in preference to bottles, we might uſe the cocoa-nut, which often lands five or ſix hundred leagues from its native ſhore, and appears formed for paſſing the ſeas. It is preſerved from violence by a coat, which in the ſwell of the fruit is from one to two inches thick, and increaſes to three or four inches at the ends. This coat is a ſmooth and tough membrane, on which letters may eaſily be etched.

Similar reſources may alſo be found among amphibious animals, ſuch as turtles, which are conveyed to great diſtances by means of the currents. I have read in the hiſtory of China, that one of its ancient Kings, attended by a great body of people, perceived a turtle coming out of the ſea, on whoſe back laws were written, which at this day

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* See Faulkner's Marine Dictionary.

" impatient to know what it contained, they " broke it :—within was a letter, whoſe addreſs " they did not underſtand, being written in " Engliſh. They took it to the Judge of the " Admiralty Court, who lodged it in his office. It " was addreſſed to an Engliſh lady. The Judge " took the neceſſary ſteps for her receiving the " letter; and her huſband (a gentleman known " in England for his eſteemed literary productions) wrote to the Judge in terms of ſincere " obligation; and informed him that the letter in " queſtion came from his brother in-law on his

day are the foundation of their empire. Probably, this legiſlator had profited of that animal's cuſtom, which comes on ſhore to examine the ſpot on which it intends to depoſit its eggs, and wrote upon its back the laws he wiſhed to eſtabliſh; and that the next day he made the ſame examination, and in the ſame place, where the turtle did not fail returning to lay its eggs; thus penetrating this ſimple multitude with the higheſt reſpect for laws which proceeded from the ocean, and with aſtoniſhment at the wonderful tablets on which they were written.

Sea birds will furniſh more ſpeedy modes of communication, their flight being very rapid; and in deſart places they are ſo familiar as to be taken by hand; a note may be faſtened to them, with ſome conſpicuous mark, being attentive to chuſe thoſe which travel at different ſeaſons, and viſit different ſhores; and the ſame of birds of paſſage, ſuch as the wood pigeon.

"paſſage to the Eaſt Indies. He wiſhed to give "his ſiſter ſome account of himſelf, and a ſhip "which he ſaw in the Bay of Biſcay, and ſeemed to be ſteering for England, induced him to "write; he expected to have got near her, but "not having done ſo, he hit upon the expedient of putting his letter into a bottle, and "truſting it to the ſea."

By way of verifying this fact, I wrote to a lady of my acquaintance in Normandy, requeſting her to aſk the Judge of the Admiralty of Arromanches, for ſome accounts I wanted from England. The following anſwer was written by the Judge, and dated the 24th of February, 1788.

"The bottle was found ſix miles at ſea, to the right of the province of Arromanches, which is nearly two leagues N. E. of the town of Bayeux, on the 9th of May 1787, and was depoſited at the Admiralty the 10th of that month.

"Mr. Elphinſton, huſband to the lady, to whom the letter was directed, obſerved, that from its date it was bottled the 17th of Auguſt, 1786, in lat. 45° 10′ N. long. 10° 56′ W.

The veſſel was a pacquet, bound to Bengal, called the Intelligence, and commanded by Capt. Linſton.

(Signed)

PHILLIPE DE DELLEVILLE."

The pariſh of Arromanches is about 1 deg. of longitude, weſt of the meridian of Greenwich, and in lat. 49° 5′ N.; the bottle then, thrown into the ſea, in long. 10° 56′ W. and lat. 45° 10′ N. traverſed about 10 degrees of longitude (which in that parallel have nearly 17 leagues to a degree), that is, 170 leagues to the eaſtward. It alſo came 4 degrees to the northward, having been taken up two leagues north of Arromanches, that is, in lat. 49° 10′ which gives 100 leagues of northing, and 270 leagues for its whole traverſe. It was 266 days in this paſſage, from the 17th Auguſt 1786, to the 9th of May 1787, which is not one league a day. This rate of going is certainly not equal to that with which the wreck of the battle of Oſtend travelled to the Azores, which made more than thirty-five leagues a day. The reader might object to the ſtatement given on that ſubject by Rennefort, and to the deductions I have infered from it, on the velocity of the general current of the ocean, did I not otherwiſe eſtabliſh it by various nautic proofs; and were not the journals of navigators replete with ſimilar circumſtances, which prove that the currents and the tides frequently carry veſſels three or four miles an hour, and even run with the ſwiftneſs of ſluices, making eight or ten leagues an hour, in the vicinity of the fuſing pole. But I may alſo aſſert that the ſlowneſs with which the letter travelled from the entrance of the Bay of Biſcay to the coaſts of Normandy, is another proof of the exiſtence and velocity of the alternate and ſemi-annual current of the Atlantic, which has been hitherto miſunderſtood; and which I aſſimilate to that of the Indian ocean, and refer to the ſame cauſe.

By conſulting the chart, it is evident the ſpot where the bottle was thrown into the ſea is more than eighty leagues from the continent, and preciſely in the projection of mid-channel, where an arm of the general Atlantic current paſſes, and in ſummer conveyed the wreck of the battle of Oſtend, as far as the Azores,

Azores. But the current alſo ſet to the ſouthward, when the Engliſh paſſenger committed his letter to the ſea, which it appears he did on the 17th of Auguſt, that is, in the ſummer of our pole, when its fuſions are ſtreaming to the ſouthward. The bottle, then, travelled as far as the Azores, and probably further, during the end of Auguſt and the whole of September; until brought back by the revolution of the equinox, which returns the Atlantic current, by the fuſion of the ſouth pole.

Its return, then, muſt only be computed from the month of October, at which time I ſuppoſe it in the vicinity of the Line, where it received the influence of the ſouth pole, which is only felt in our hemiſphere towards the month of December. At this time the current of the Atlantic, which ſets to the northward, being the ſame with that of our tides, the bottle might eaſily be neared to our ſhores, and expoſed to great delays, by rivers croſſing its courſe, where they fall into the ſea, but chiefly by the reaction of the tides; for if the flood ſets to the northward, the ebb, of conſequence, checks to the ſouthward.

It is, then, neceſſary to make ſuch experiments in the open ſea, and to take eſpecial notice of the current of the ocean, to avoid ſending letters to the ſouth, which were intended for the north. During the ſeaſon in which the current is not favourable, the tides, which run in oppoſite directions, may be brought into uſe; but ſubject to the inconvenient delays I have juſt noticed.

The tides, in their flood and their ebb, are in perfect conformity with the general currents of the ocean, and with the courſe of the ſun. They flow for twelve hours in the day, whether they are again divided into two tides of ſix hours, by the fuſions of the two continents, as in the northern hemiſphere; or, whether they continue for twelve hours, as in the ſouthern hemiſphere. Thus alſo the general current of each pole continues for ſix months in the year. The tides, then, which uniformly flow for twelve hours, are in duration, equal to the time employed by the ſun, in heating one half of the polar circle, from whence they proceed; that is, of half a day; and the general current, which iſſues from that pole, ſtreams for exactly the ſame length of time, which the ſun employs in heating that hemiſphere, that is, for half a year. But as the tides, which are merely polar fuſions of half a day, have an ebb equal to their flood, that is, of twelve hours; ſo the general currents, which are ſemi-annual fuſions of one entire pole, have a reflux equal to their flux, that is, of ſix months, when the ſun brings thoſe of the oppoſite pole into activity.

If circumſtances permitted, I could ſhow how theſe general currents, which are the ſecondary cauſes of the tides, ſometimes advance our navigators, and ſometimes retard them, according to the ſeaſon of the poles. I ſhould find a multiplicity of proofs, in the voyages made round the world; among others, in the ſecond and third of Capt. Cook. Theſe currents often occaſion the greateſt delays to ſhips approaching the land,—as in the inſtance of Capt. Cook, who left the iſland of Otaheite in December 1777, to proſecute his diſcoveries to the northward; on his paſſage he diſcovered the Sandwich Iſlands, where he landed without delay, the currents of the ſouth pole being then favourable to him; but when in the ſame ſeaſon he returned to theſe iſlands from the north, to procure refreſhments, this current was ſo much againſt him, that though he made the land on the 26th November 1778, he was upwards of ſix weeks beating againſt the wind into anchorage, which he only reached the 17th January 1779. It appears, then, that the proper ſeaſon for paſſing to iſlands higher in latitude, is during their winter, being then aſſiſted by the currents of the oppoſite hemiſphere; and is proved by the firſt voyage of Captain Cook to the Sandwich Iſlands; — the reverſe of courſe takes place when ſailing to iſlands leſs elevated in latitude, as in the inſtance of Capt. Cook's return.

Far be it from any man to taint the reputation of Newton, and of thoſe who have moved in his ways. If they have occaſionally induced us into error, they have uniformly contributed to enlarge the human mind; but ſuch is the order of our exiſtence, that each individual may have reference to nature; her intelligence enlightens every capacity; and the contemplation of her works, in eſtabliſhed ſyſtems, is but accepting the opinion of men.

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TRANSLATOR's

APPENDIX.

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ST. Pierre, throughout the whole of his work, differs with many great names, on many great ſubjects; and confining himſelf to facts, he urges explanation. On the queſtion before us he directly differs with Sir Iſaac Newton, referring his opinions to the beſt, and lateſt authorities.

The world is every year more equal to aſcertain exiſting facts, on which all ſcience muſt ultimately depend. Navigation, ſince Sir Iſaac Newton's time, has taken its utmoſt range, and diſcoveries are puſhed with ſo much vigor, that nautic ſyſtems are either maintained or refuted by numberleſs obſervations. It is very well known to a commonly intelligent mariner, that the laws of attraction will not hold good in the various calculations made on the ſubject of tides, and that reference muſt at all times be had to the poſition of head lands, deep bays, great rivers, ſand banks, &c. &c ; and even after ſuch obſervations, the tides are ſtill ſubject to winds and land floods. Upon getting at any conſiderable diſtance from the ſhores of the continent, it is found very difficult to aſcertain the velocity of the current, becauſe, it is not poſſible to argue from any fixed point. The ſea is too deep to anchor a ſhip, and between a veſſel, and a boat, and a caſk, we are only able to get at relative velocity. When ſailing weſt, by attending to the daily obſervations, ſuppoſing them not to be interrupted, we may, by correcting the error of the reckoning, eſtimate a mean current ; but this again depends on croſſing the actual current at right angles, for if that be deviated from, the calculation becomes totally unfounded. That ſuch currents exiſt, is needleſs to attempt proving ; for it is ſelf-evident, that if the ſea is in motion, in the whole extent of the continents we are acquainted with, the ocean muſt alſo have its portion of movement ; but it does not follow it muſt have the ſame. I am not about to add any arguments againſt the received opinion of the moon's influence ; I only wiſh to clear my own mind of ſentiments

ments, which I have received more upon authority than conviction; and to lay the foundation of my opinions in evidence.

Upon firſt reading St. Pierre, I was ſtruck to conviction with the truth of his reaſoning; and I made inquiry of perſons, who I hoped would give me more inſight into the ſubject than I allowed myſelf to poſſeſs; and I found that St. Pierre was treated as a viſionary; I could not give up my conviction, though I certainly did my confidence, conceiving the author might, perhaps, be more ingenious than ingenuous, till reading him again and again, I determined to tranſlate him, as the ſureſt mode of detecting the viſionary, and when I had compleated the whole theory of tides, I found myſelf as great a viſionary as St. Pierre.

"From the cradle to the grave," we are perpetually induced to acknowledge, that nothing is ordered by Infinite Wiſdom, without a fixed, though not perhaps an evident intention. The poſition, then, of the continents, and, in general, the partition of land and waters, on the globe, muſt neceſſarily have reference to ſome object, and upon St. Pierre's theory, one of thoſe objects preſents itſelf to our reflection.

I mean that of guiding the fuſions of the cupolas from pole to pole, and enforcing them to perform the circuit of the world.

The north pole is ſurrounded by water, and that water is again incloſed by land, between the 80th and 85th degree of latitude, having only two outlets for the fuſions of the pole, the one between Europe and America, and the other between America and Aſia; of theſe two, the firſt is conſiderably the largeſt, and of courſe vents the greater body of water.

The globe, conſidered in a birds-eye view, from the north pole towards the ſouth, is divided into two projecting continents, for in this diviſion I adopt the partition of nature, not that of geographers. I conſider Europe, Aſia, and Africa, as one continent, the two Americas as a ſecond continent, — waters then iſſuing from the north pole, can only find their way down the Atlantic canal, or into the ſouth ſea, by Behring's Straights.

Theſe continents preſent us with a ſucceſſion of lakes.—The firſt ſurrounding the north pole, with two outlets; the next called the North Atlantic Ocean, with one outlet towards the equator,—

equator,—the other called the South Atlantic Ocean—the fourth called the Indian Ocean—the fifth called the Great South Sea—and theſe again ſubdivided into many leſſer lakes.

The firſt of the two continents projects from the north pole, to the 34th degree of ſouth latitude; and the bearing of the compaſs from the weſtermoſt cape of the coaſt of Guinea to the Cape of Good Hope, is nearly N. W. and S. E.

The ſecond continent projects from the north pole to the 55th degree of ſouth latitude, and the bearing of the compaſs from Cape St. Auguſtine to Terra del Fuego, is nearly N. E. and S. W.

The moſt weſtern projection of the firſt continent, is about Cape de Verd, in nearly 12° north.

The moſt eaſtern projection of the ſecond continent, is near Cape St. Roque, or St. Auguſtine, in about 5° S.

But as Cape de Verd lies conſiderably to the northward of the line, and Cape St. Auguſtine to the ſouthward, it is evident that a current from the north pole, arivng at thoſe capes, muſt between them, neceſſarily deviate from its firſt direction, and acquire one parallel to them. By examining the chart of the world, we find that immediately to the ſouthward of the Cape de Verd, the continent of Africa opens into a large gulph, admitting and favoring this enforced direction; and that the Cape of Good Hope lies exactly in the parallel mentioned, directing the currents to the ſouthward of Africa.

It muſt be remembered, that, during the fuſion of the north pole, the ſouth pole is accumulating ice, and does ſo in winter to the 65° degree of latitude; ſo that from the ſouth pole, to the extremity of the cupola, we muſt admit of a ſolid continent of ice, occupying four and twenty degrees of the meridian.

If then we follow the current, guided between America and Africa, into a S. E. direction, we ſhall find that upon meeting the waters ſouth of the Cape of Good Hope, it will communicate and receive a N. E. direction; the angle of refraction being equal to the angle of incidence.

The monſoon then ſeems clearly to follow this principle.

Is it aſked, why the current does not in part take to the S. W.? The reaſon to me ſeems ſelf evident—Cape Horn projecting to the 55th degree of ſouth latitude, and the cupola riſing to the 65th degree (ſuppoſing it no higher), this paſſage, compared to that between be-the Cape of Good Hope and the cupola, is in reality reduced to a ſtraight; and the waters to the eaſtward of Cape Horn, being but intermittently impelled by the parent ſtream, which is directed S. E. are only endued with ſufficient movement to create the tides on the coaſts of America, and to replace the waters abſorbed by the freezing pole.

Before we leave the Atlantic ſeas, let us conſider the purport of the Gulph of Mexico.

The exceſs of water which is unable to paſs the ſtraights of America and Africa, is in part turned to the north in a counter current, or eddy, on the ſhores of the firſt continent; and in part takes a weſtern direction towards the windward or Carribee Iſlands.—Theſe iſlands are placed north and ſouth, and by that poſition check the regularity, but increaſe the velocity of the current, which when again in the open ſea, to leeward of Saba, St. Euſtatia, St. Kitt's, Montſerrat, and Guadaloupe, depoſits the ſediment acquired among the iſlands, and forms the Bank of Aves, which probably is in continual increaſe.

But beyond the Carribees, we find iſlands of totally different ſhape and poſition — Porto Rico, Hiſpaniola, Jamaica and Cuba, lay longitudinally, and direct the current to the weſtward, between their ſouthern ſhores and the north coaſt of the Spaniſh main.

It is alſo here to be obſerved, that the paſſages between theſe iſlands are very neceſſary, not to navigation only, but to the ſurrounding ſhores, as outlets, ſhould the current grow ſtronger than uſual, or as inlets, ſhould it weaken.

Proceeding to the weſtward, we muſt next attend to the great baſon or reſervoir of Mexico, apparently proportioned to the quantity of water it is to receive.—The firſt great feature we find is the peninſula of Yucatan, projecting nearly north, and forming a ſtraight between Cape Catoche and Cape Antonio; Cape Catoche is rather to the ſouthward of Cape Antonio, and conſequently directs the current to the weſtward of north.—But the gulph being in itſelf a ſtationary water, is only affected by the rivers which fall into it, and by the impelling power of the current, which forces itſelf round Cape Antonio, between the Keys and Cuba; being again turned north by the poſition of the great bank of the Bahamas, and joined by a branch of the general current, which took to the northward of Porto Rico, Hiſpaniola and Cuba, and re-unites itſelf with the parent current between the Pan of Matanzas and the Bahamas.

Hence, the current puſhing north, takes the name of the Gulph Stream, and directed by the coaſts of America and Newfoundland, falls again into the polar fuſion.

The ſame mode of reaſoning is evidently applicable in a leſs extenſive degree to the Gulph of Guinea, during the fuſions of the ſouth pole.

We muſt now proceed to the Indian monſoon, which was obſerved ſetting to the N. E.

Having paſſed the Indian ſeas, and running between China and New Holland, its velocity is there increaſed by being iſſued through the Straights of Sunda, but eſpecially through Endeavour Straights, and according to St. Pierre, it reaches the Pacific ocean, ſometime in May.—But the fuſion of the north pole having been in proceſs, from the month of March, the Straights of Behring have for three months been venting their columns of water, to which muſt be added the progreſſive northern fuſions of the continents of Aſia and America, encloſing the Pacific ocean, and diſcharging themſelves immediately into it.—Theſe ſucceſſive and united cauſes muſt neceſſarily impel the Pacific fuſions to the ſouthward, and meeting the monſoon current, running into that ocean, between New Holland and China, will naturally combine their directions, forming a diagonal towards Cape Horn, and paſs the ſtraights between the cape in 55 ſouth, and the cupola of ice in 65 ſouth, and join the parent current, having nearly made the circuit of the globe, between the months of March and July.

A branch of the N. E. monſoon, runs to the ſouthward of New Holland, and meets the northern current which took through Endeavour Straights, ſomewhere about New Zealand; for we find that Sumatra lies N.W. and S.E. ſtopping the courſe of the N.E. monſoon, and inclining it partly to the northward of Sumatra into the Bay of Bengal, and partly through the Straights of Sunda, but chiefly through Endeavour Straights, the iſlands of Java, Combava, Flores, Timor, &c. to the eaſtward of Sumatra, lying longitudinally.—But the iſland of Papua, or New Guinea, lying S.E. by E. and N.W. by W. inclines the current to the S.E. interſecting the current which paſſed to the ſouthward of New Holland, ſomewhere about New Zealand. It is alſo to be noticed that the Gulph of Carpentaria (like thoſe of Mexico and Guinea), is ſituated to receive the exceſs of waters which do not paſs through Endeavour Straights.

The fuſions of the ſouth pole are conſiderably greater than thoſe of the north pole, as St. Pierre has noticed—but their direction, at firſt ſight, is not quite ſo apparent, becauſe not ſo reſtrained as thoſe of the oppoſite hemiſphere. But conſidering the effect of the fuſion of the ſouth pole upon a globe (which is the only fair and certain way of judging), I fancy we ſhall ſoon trace them to the channels before alluded to, though proceeding in a contrary courſe.

When the ſouth pole begins to fuſe, it will appear that Cape Horn projecting ſo far towards the ſouthern cupola, muſt of neceſſity divide the iſſuing waters into two major and many ſmaller currents; the firſt of the major currents taking due north, between Cape Horn and the Cape of Good Hope; and the ſecond to the weſtward of Cape Horn.

That taking due north, between Cape Horn and the Cape of Good Hope, will ſoon find itſelf ſimilarly circumſtanced with its oppoſite northern current; for being confined between America and Africa, it will puſh through into the Atlantic, and impel it to the northward, along the coaſts of Africa and Europe; a branch will naturally take the courſe of the Weſt Indies, and ſupply the gulph ſtream.

The exceſs of the firſt current will return S.W. along the coaſt of Brazil to the Straights of Magellan, and eaſt into the Gulph of Guinea, which appears to be a ſmaller gulph of Mexico, as intended for a ſmaller object, that of carrying off the exceſs of waters, without reconveying them to their ſource at the ſouth pole.

The current taking to the weſtard of Cape Horn, will neceſſarily go to the northward, till the weight of the monſoon partly directs it to the weſtward, and ſets it through Endeavour Straights, &c. there commencing the eaſtern monſoon, and running round the Cape of Good Hope, joins the current firſt alluded to, which paſſes north between the ſhores of America and Africa.

The poſition of New Holland muſt certainly determine the weſtern monſoon, the waters being not only propelled between it and China, by the winds from the eaſt, but drawn from thence towards the Cape of Good Hope, to ſupply the conſtant drain towards the north, which takes place between Africa and America, in a direction for the oppoſite and freezing pole.

The ſouth cape of Van Dieman's Land, in New Holland, is ſituated ſomething like Cape Horn, and divides the fuſion of the ſouth pole, which yields an entire circle of ſucceſſively projected fuſions, into two leſſer currents, the one following the eaſtern ſhores of New Zealand, till it falls into the major current, paſſing between New Holland, and China; the other going to the weſtward of New Holland, and alſo joining the weſtern monſoon.

I truſt then I have, without forcing facts, accounted for the prominent features of the globe—time only will give us more inſight into the leſſer. Indeed I cannot but hope the ſubject may intereſt ſome of thoſe who navigate the diſtant, as well as the nearer parts of our globe; I muſt obſerve, that St. Pierre is perfectly aware his theory is in its infancy, and, I believe, would ſay, with my Lord Bolingbroke*, that "It has been the pride and folly "of men of all ages, to impoſe compleat "ſyſtems on the world; whereas all human "knowledge, in its utmoſt extent, is deficient, "and a ſyſtem that affects to be, and that ap"pears to be compleat, is therefore falſe."

The more indeed we inſpect the globe, the more evidently it appears, that the continent and the iſlands are ſituated for ſuch directing purpoſe. If any reaſons have been adduced for the order in which we find them placed, it has been my misfortune not to have met them in print or converſation; and, as I have before hinted, it is impoſſible to admit them ſo ordered, without deſign.

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* Philoſophical Works, Vol. II. eſſ. 4, p. 381.

St. Pierre ſeems uniformly the opponent of unſupported theory, yet he does not refuſe,

> "Analogy, man's ſureſt guide below."

I ſhould therefore conclude he muſt have ſome general conceptions on the ſhape of the concave, which contains the waters of the ocean. I muſt premiſe that the conjectures I am about to add, are merely given as ſpeculation; it however is certain, that the bottom of the ocean is of very unequal depths; and that thoſe aſcertained by the lead, do not generally exceed 250 fathoms. — Beyond a certain depth, no man has felt the lead upon the ground; what then is the ſhape of that ground, when beyond our reach?—From the ſhore we extend to certain ſoundings, and beyond thoſe I cannot but imagine that the ſea continues gradually deepening to its greateſt depth, ſomewhere between the two ſhores, incloſing it, and forming a channel within a channel, like that between ſands in an extenſive river. If, then, the ſhape of the inner channel ſhould be ſuch as to anſwer to the correſponding ſhores, and beyond them to the circuitous courſe of the general current, we ſhall ſtill more clearly account for the immediate courſes into which the fuſions are directed. For inſtance, if the North Atlantic Ocean, ſhall be found deepeſt in a line ſouth from the northern ſluices—if the South Atlantic Ocean, ſhall be found deepeſt in a line parallel to the Capes St. Auguſtine and de Verd,—if at the Cape of Good Hope, the Author of Nature has diſpoſed of a tongue, advancing far ſouth towards the ſouthern cupola,—if another tongue is diſpoſed with ſimilar intent, to the ſouth of Cape Horn,—if the Indian Ocean ſhall be found deeper between New Holland and the Cape of Good Hope, than between Sumatra and the northern part of Madagaſcar ;—if the South ſea ſhall be found deepeſt in the direction of Cape Horn and the Sandwich iſlands,—and if the ſame law is diſcovered

covered in other ſituations relatively placed, it will, I imagine, be granted, that the circuitous courſe deſcribed by the polar fuſions, not only depends on the viſible works of creation, ſo manifeſtly exhibited in the poſition of the old and new world, but in its inviſible diſpenſations beneath the waters of the ſea.—I am not at preſent furniſhed with ſufficient certainties on the ſubject, and ſhall therefore content myſelf with hazarding an opinion, which, though not founded upon facts, is, to my apprehenſion, ſupported by analogy.

To aſcertain the truth on this ſubject, I ſhould think Mr. Greenſtreet's ſea gage might be very uſefully employed. It is the only invention of the kind which appears to me ſimple and practicable; and does infinite credit to the ingenious inventor. An account of it is given by Mr. Charnock, in the Repertory of Arts,* accompanied with a plate, deſcriptive of its ſimple machinery.

I muſt add one obſervation upon St. Pierre's reaſoning with reſpect to the elliptic form of the poles. He appears to me either to miſconceive or miſtate part of the received ideas on that ſubject; I did not, however, feel myſelf at liberty to withold any theory connected with that of his tides, and have therefore printed it, and given his own diagram.

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* Vol. II. p. 180.

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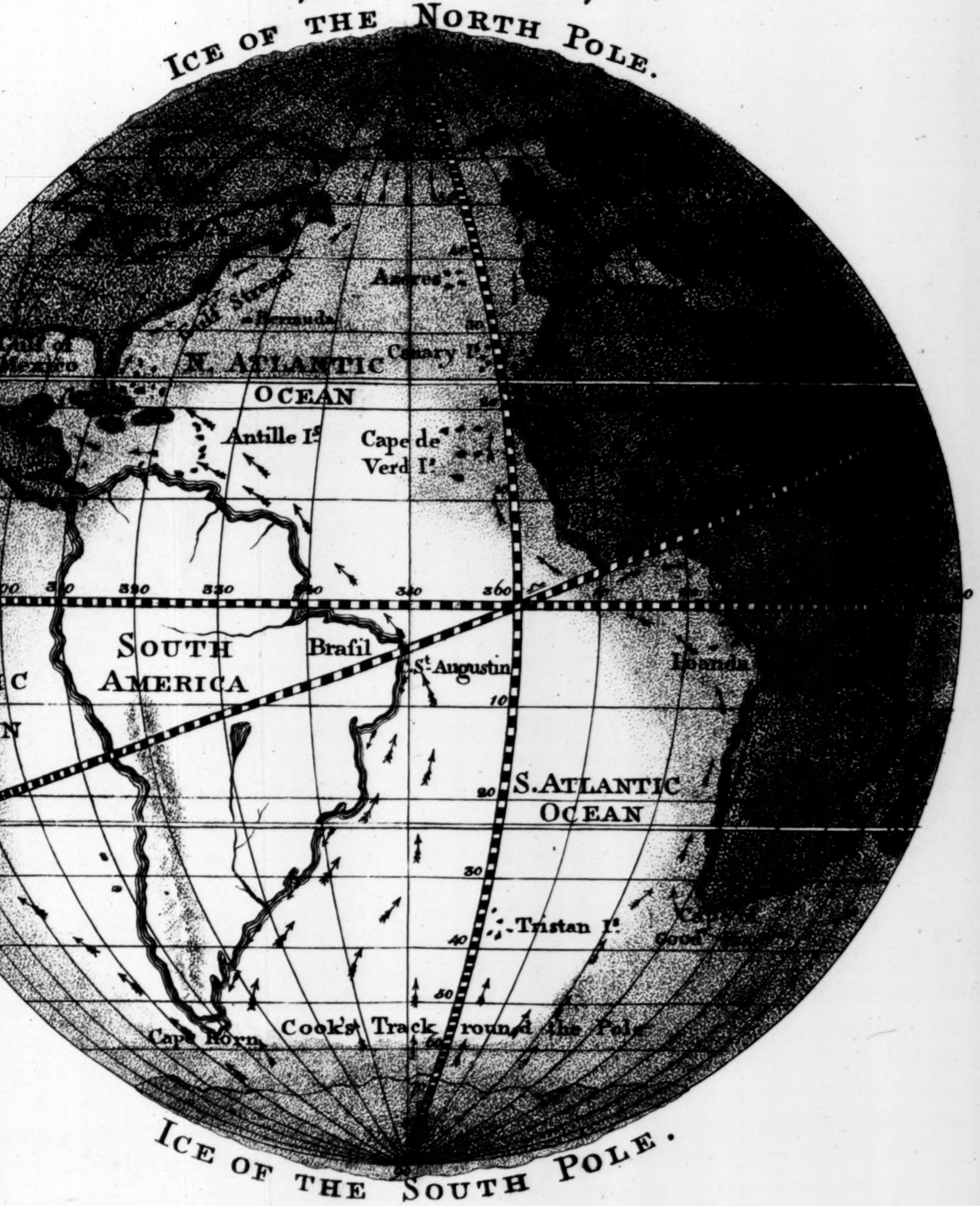
Theory of Tides: Plate 1st

ATLANTIC HEMISPHERE,

ts Canal, Ice, Currents, & Tides, during the Months of
January and February.



J. Hibbert, Bath, Sculp:
Febr. 1795.

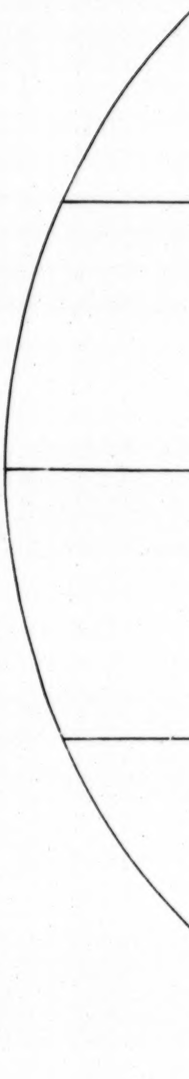
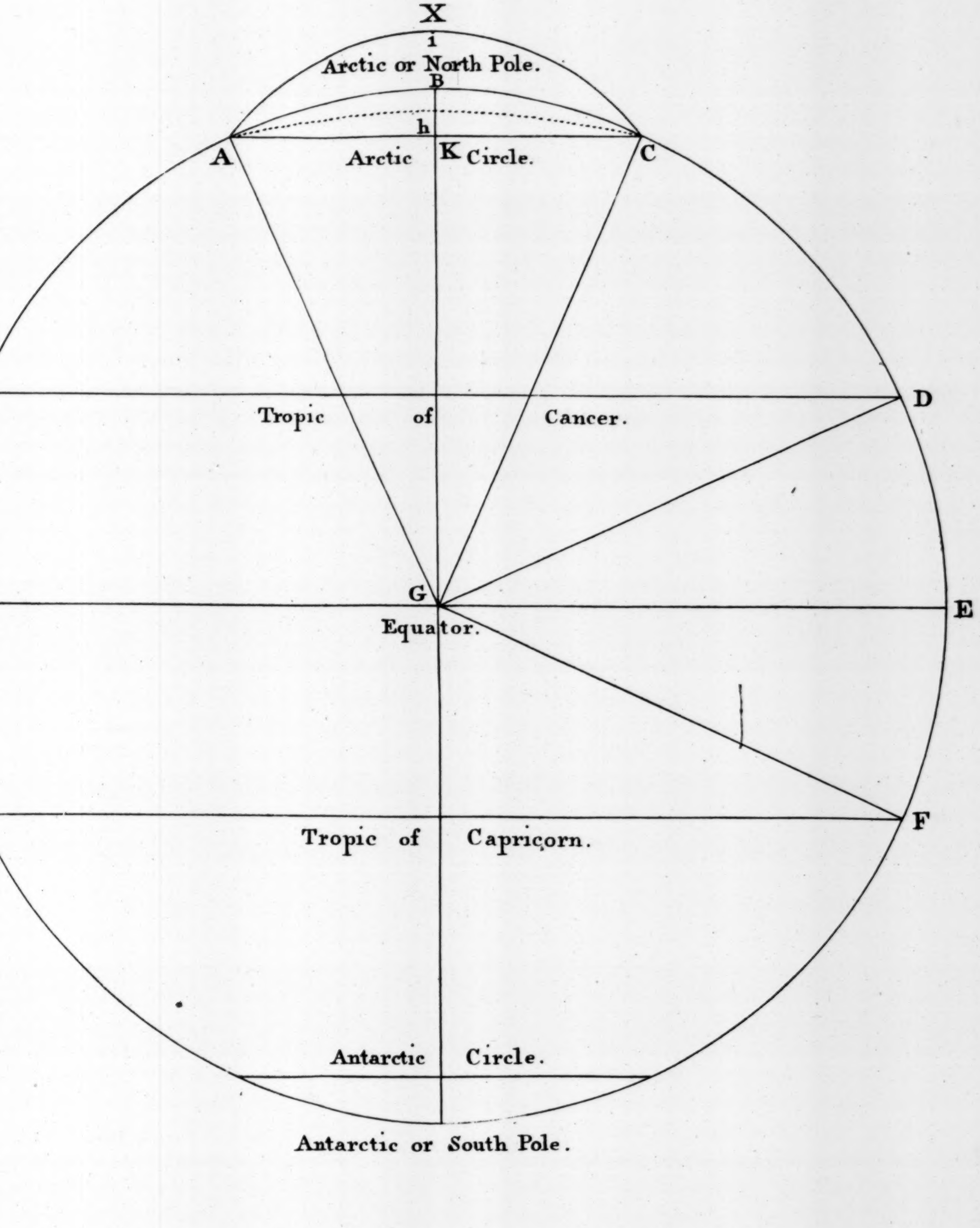


Plate 2nd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